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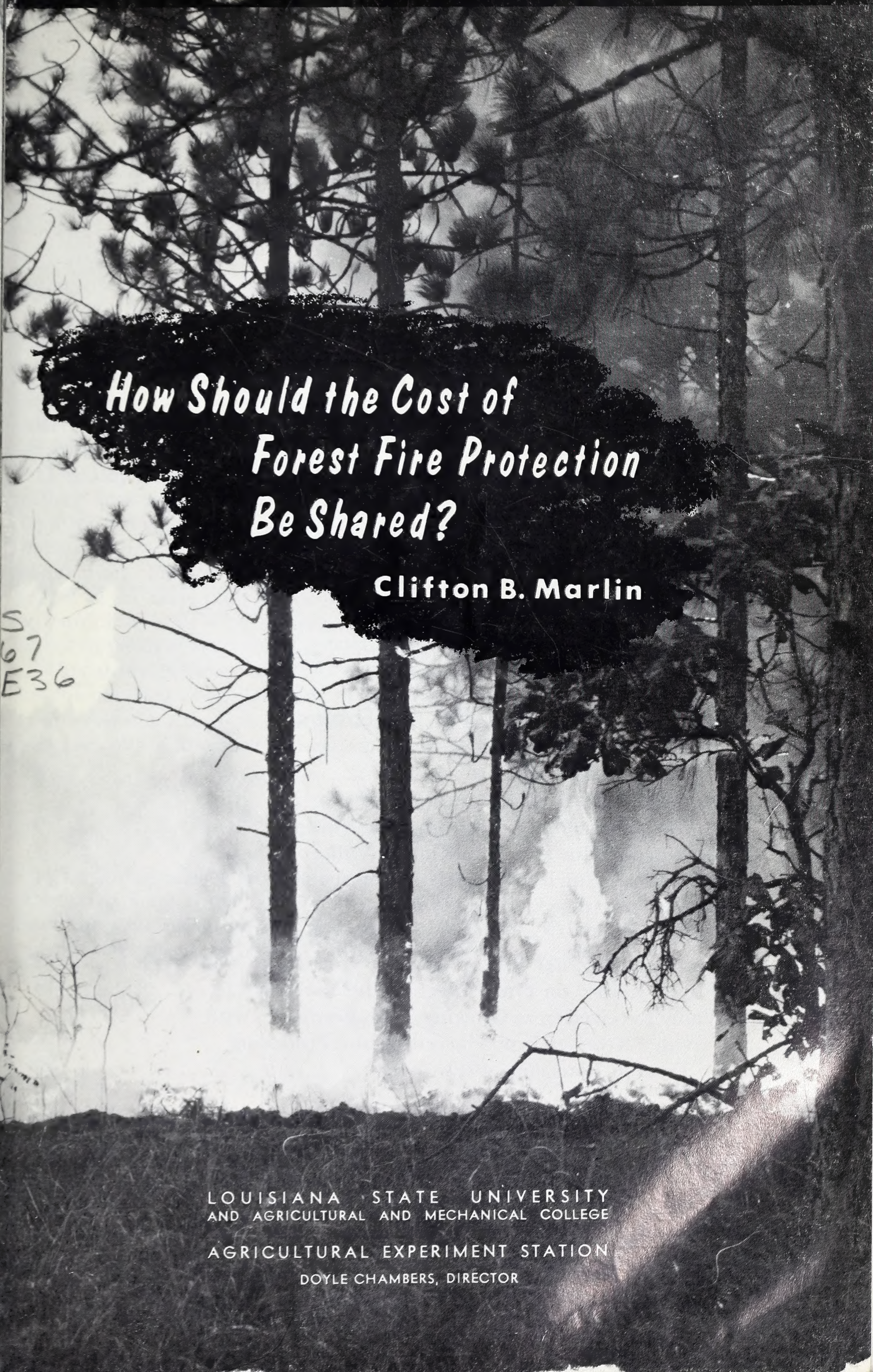

How Should the Cost of Forest Fire Protection Be Shared?

Clifton B. Marlin

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Preface

Taxation is an item of expense for all forms of private enterprise, and the business of growing trees must carry its fair share of the tax burden. In any study of taxation, it should be fully recognized that local, state, and federal governments must have the funds required to carry out programs established by law.

The objective of a study in forest taxation should, therefore, be to collect facts and develop procedures which would lead to sound forest taxation from the standpoint of the forest landowner, the forest products industry, the various governments, the general public, and the application of taxation. The goal should be to develop a fair-share basis of taxation for all of the taxes paid by the forest landowner so that he may be put on an equitable basis with owners of other taxable property in meeting the financial needs of the various governments.

This study involves only one of the several taxes paid by the forest landowner. It is an initial study of forest fire protection costs in Louisiana and involves a collection, analysis, and interpretation of facts to determine how the costs of forest fire protection should be shared.

Acknowledgments

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How Should the Cost of Forest Fire Protection Be Shared?

Clifton B. Marlin*

Almost everyone concerned with the cost of forest fire protection has an opinion as to who should pay the cost, but no one has been found who has the facts to support his position.

The purpose of this study is to present essential facts on forest fires in Louisiana. and to evaluate these facts in the light of sound criteria bearing on private and public responsibility.

Records covering a period of years have been studied, and information has been extracted where it was found to have value in establishing a basis for sharing fire protection costs.

Basis for Cost Sharing

Many people having a knowledge of this problem were questioned and reviews of the literature were made in an effort to determine a basis for sharing the cost of forest fire protection from the standpoint of private and public responsibility. Personal opinions varied widely. A majority of the people giving opinions expressed a philosophy that the federal and state governments should pay most of the costs of forest fire protection since these agencies have a strong interest in national defense, business, conservation, water, recreation, and the taxes which come from economic activity. A small number of people were of the opinion that the forest fire protection tax paid by the forest landowner should be increased because of inflation and intensification of the program.

Very few references and guidelines were found in the literature, inasmuch as little study has been devoted to this problem. The techniques found to be applicable were used. One reference had a section dealing specifically with the evaluation of public forestry programs, and the following is quoted from it: "Where public programs are administered on private lands, or where some of the benefits from programs administered on public lands accrue to private interests, it is desirable to determine the division of responsibility between social and private interests. In either case the generally accepted principle applies—that the recipients of benefits should pay the costs involved, if they are economically justified, in proportion to the benefits received—and it is only by evaluation that an adequate basis can be established for determining the respective public and private responsibilities."[1]

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This principle applies to the study of forest fire protection costs, and indicates that costs of forest fire protection should be paid jointly by the people who cause forest fires and the people who reap the benefits from productive forests. Furthermore, this payment should be in proportion to the extent that a person contributes to the starting of forest fires, and to the extent that he or she benefits from productive forests. This study was made on the basis of these criteria.

Authority for Forest Fire Protection

The founding fathers of the State recognized the importance of forestry to the economy of the people of Louisiana and stated in the Constitution of 1921 that forestry "shall be practiced in the State." The State Legislature was also given power in the Constitution to authorize the governing boards of the parishes to levy an acreage tax, not to exceed 2 cents per acre, to help encourage forestry.

When enacted into law, this tax covered forest land only, and was established for the purpose of protecting forest lands and cutover potential forest lands from damage by fire and other causes. The law authorized police juries, as governing bodies of the respective parishes, to either appropriate money for this purpose from the parish general fund or to levy an annual acreage tax, not in excess of 2 cents per acre, on forest lands and on cutover potential forest lands which were not classified as town sites, as lands used primarily for agriculture, or as lands fenced and used for pasture purposes.

Under this authority, parishes have, in increasing numbers, levied this tax and entered the forest fire protection program administered by the Louisiana Forestry Commission. The levy, with a few exceptions, has been made on the forest landowner rather than appropriated from the general fund and the amount has been the maximum of 2 cents per acre. The exceptions involve a small number of parishes in the hardwood area along the Mississippi River, locally called the Louisiana Delta. Forest fire expenditures to date have been much lower in the Delta than in other areas of the state. Therefore, the assessment is set at less than 2 cents per acre in recognition of the short fire season and the lower expenditure when compared with non-Delta parishes. Funds for forest fire protection costs are allocated from the general fund in three Delta parishes in lieu of the acreage tax. The procedure followed in these three parishes is felt to be sound inasmuch as the administrative cost involved in assessing and collecting the tax would probably be less efficient than the method now used.

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[1] William A. Duerr and Henry J. Vaux, eds. 1953. Research in the Economics of Forestry. Pack Forestry Foundation. Washington, D.C.

Who Causes Forest Fires?

In determining a proportionate sharing of the costs for forest fire protection, it is necessary to find out who is responsible for starting forest fires. An important point is that less than 1 per cent of the fires in Louisiana are due to natural causes, while over 99 per cent are caused by people. Some of these fires are caused either by the landowner directly or by operations over which he has some control. Other fires result from actions of people other than the owner.

The fire records of the Louisiana Forestry Commission contain information on the number of forest fires, by cause, for each year. These records provide an excellent basis for determining the number of fires caused by forest landowners, and the number caused by others. Fire causes listed by the Louisiana Forestry Commission are incendiary, debris burning, smokers, campers, lumbering, lightning, railroads, and miscellaneous.

Fires Charged to Forest Landowners

Forest fire records of the Louisiana Forestry Commission were studied for the period from 1933 to 1961. The following causes of fires were charged as a forest landowner responsibility:[2] (1) fires due to all phases of lumbering; (2) fires due to lightning; (3) one-half of the fires due to debris burning; and (4) pro rata share of the miscellaneous fires.

Fires due to felling, bucking, skidding, loading, hauling, and sawing timber products (classified as lumbering) are charged to the forest landowners. Although these operations are usually not performed directly by the landowner, they constitute an industrial operation over which he can exercise some degree of control.

In this study, fires caused by lightning are charged to the forest landowner. While the forest landowner does not cause fires due to lightning, it was felt that the cost of protecting against or sustaining the loss from fires due to acts of nature should be an obligation of the landowner.

Debris burning is a category set up to include all fires caused by land clearing, and brush and trash burning. Some of these fires are caused by forest landowners, some by landowners without forest land, and some by people that do not own land of any type. Since it was impossible to assign responsibility for debris-burning fires with exactness, half of these fires have been charged to the forest landowner and half to others.

The miscellaneous fires in the Louisiana Forestry Commission reports are the only fires which could not be attributed to known causes. These have been charged to forest landowners and to others in proportion to the extent that each group was responsible for forest fires where the cause was known.

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[2] In 1958, personnel of the Battelle Memorial Institute, Columbus, Ohio, made a study of the cooperative forest fire control problem in the United States. The basis for assigning responsibility for forest fires to forest landowners and to others in the Battelle study was the same as that used here.

As an example, there were 10,888 fires in 1952. Miscellaneous fires accounted for 1,300 of the total, leaving 9,588 fires which were assigned to known causes. The forest landowner was responsible for 775, or 8.08 per cent, of the fires attributed to known causes that year; others were responsible for the remaining 8,813, or 91.92 per cent. On this basis, 9,588 x .0808, or 105 miscellaneous fires, were charged to the forest landowner, and 9,588 x .9192, or 1,195, were charged to others. This procedure was followed for each year so that miscellaneous fires were charged to the forest landowner and to others on a proportional basis.

The generally accepted procedure for dividing responsibility for fire control costs is to make the costs proportional to the number of fires caused. This principle was used as a basis for dividing responsibility for forest fire control costs between the forest landowner and others.

The numbers of fires due to the above causes were tabulated by years (Table 1), and expressed as a percentage of the total number of fires (Table 2).

Fires Charged to Others

Forest fires due to the following causes were charged as being the responsibility of persons other than the forest landowner: (1) incendiary; (2) smokers; (3) campers; (4) railroads; (5) half of the fires due

Records show more than 99 per cent of Louisiana forest fires, such as this one in a stand of 28-year-old pines, are caused by people.

TABLE 1.—Number of Fires by Year, Cause, and Responsibility, 1933 to 1961

Year	Fires charged to the responsibility of landowner					Fires charged to the responsibility of public						
	Debris burning[1]	Lumbering	Lightning	Miscellaneous[2]	Total	Incendiary	Campers	Smokers	Miscellaneous[2]	Railroads	Debris burning[1]	Total
1933	38	100	5	40	183	1,197	43	167	410	31	37	1,885
1934	72	80	7	45	204	1,321	40	178	463	26	73	2,101
1935	45	71	14	48	178	1,339	34	179	600	25	45	2,222
1936	90	151	12	66	319	2,252	74	286	726	61	90	3,489
1937	38	113	6	34	191	939	29	139	250	26	37	1,420
1938	74	158	8	61	301	1,989	44	397	665	88	74	3,257
1939	110	223	4	146	483	2,071	62	321	1,134	47	110	3,745
1940	86	100	1	75	262	1,548	32	165	749	27	87	2,608
1941	108	51	5	13	177	2,149	57	296	203	45	108	2,858
1942	152	71	1	32	256	2,887	81	388	495	64	152	4,067
1943	120	119	12	39	290	2,427	48	273	462	73	119	3,402
1944	33	68	6	11	118	1,765	18	148	199	28	34	2,192
1945	51	21	1	6	79	1,827	22	97	156	12	52	2,166
1946	88	27	3	11	129	2,119	19	185	222	18	89	2,652
1947	249	72	10	15	346	3,778	46	443	207	42	248	4,764
1948	296	221	10	32	559	3,159	70	586	258	69	297	4,439
1949	257	55	4	30	346	1,607	44	268	215	27	256	2,417
1950	291	111	13	59	474	3,242	35	520	608	62	290	4,757
1951	581	132	13	146	872	4,664	104	726	1,240	56	581	7,371
1952	575	183	17	105	880	6,355	243	1,573	1,195	67	575	10,008
1953	370	169	10	62	611	4,154	164	775	626	39	370	6,128
1954	596	235	56	133	1,020	7,235	267	1,379	1,430	76	595	10,982
1955	215	137	24	63	439	4,641	65	57	850	34	214	5,861
1956	309	198	81	114	702	4,327	51	595	1,044	118	308	6,443
1957	83	34	3	14	134	1,768	10	144	242	104	83	2,351
1958	219	50	6	9	285	3,389	131	345	132	58	220	4,274
1959	304	65	14	16	400	4,047	389	594	233	100	305	5,667
1960	271	92	40	7	411	2,569	336	2,398	104	148	272	5,826
1961	127	39	6	3	175	1,892	156	1,008	68	88	127	3,339
Total	5,848	3,146	392	1,435	10,824	82,657	2,714	14,630	15,186	1,659	5,848	122,691

[1] Since it was impossible to assign responsibility for debris burning fires with exactness, half of the fires due to this cause were charged to the landowner and half to the public.

[2] The miscellaneous fires in the Louisiana Forestry Commission report are fires which could not be assigned to a known cause. These fires have been assigned to the forest landowner and to others on a pro rata basis so that a proportional number is charged to the landowner and a proportional number is charged to the public.

TABLE 2—Analysis of Forest Fire Protection Cost in Louisiana, 1933 to 1961, Inclusive

Year	Total fires on protected areas	Total expenditures per acre for fire protection	Fire protection costs per acre paid by landowner	Total fires charged to landowner	Total protection costs paid by landowner	Fire protection costs per acre paid by public	Total fires charged to public	Total protection costs paid by public
	No.	Dollars	Dollars	Per cent	Per cent	Dollars	Per cent	Per cent
1933	2,068	.025	.02	9	80	.005	91	20
1934	2,305	.019	.02	9	100	0	91	0
1935	2,400	.020	.02	7	100	0	93	0
1936	3,808	.021	.02	8	95	.001	92	5
1937	1,611	.023	.02	12	87	.003	88	13
1938	3,558	.024	.02	8	83	.004	92	17
1939	4,228	.025	.02	11	80	.005	89	20
1940	2,870	.031	.02	9	64	.011	91	36
1941	3,035	.065	.02	6	31	.045	94	69
1942	4,323	.049	.02	6	41	.029	94	59
1943	3,692	.046	.02	8	43	.026	92	57
1944	2,310	.062	.02	5	32	.042	95	68
1945	2,245	.057	.02	4	35	.037	96	65
1946	2,781	.064	.02	5	31	.044	95	69
1947	5,110	.075	.02	7	27	.055	93	73
1948	4,998	.102	.02	11	20	.082	89	80
1949	2,763	.095	.02	13	21	.075	87	79
1950	5,231	.095	.02	9	21	.075	91	79
1951	8,243	.121	.02	11	17	.101	89	83
1952	10,888	.121	.02	8	17	.101	92	83
1953	6,739	.111	.0185	9	17	.091	91	83
1954	12,002	.132	.0185	8	14	.112	92	86
1955	6,300	.146	.0185	7	13	.126	93	87
1956	7,145	.123	.0179	10	15	.103	90	85
1957	2,485	.146	.0178	5	12	.126	95	88
1958	4,559	.138	.0178	6	13	.118	94	87
1959	6,067	.153	.0178	7	12	.133	93	88
1960	6,237	.166	.0178	7	11	.146	93	89
1961	3,514	.194	.0178	5	8	.174	95	92
	133,515							

to debris burning; and (6) pro rata share of the miscellaneous fires.

Fires resulting from the causes listed above are not felt to be the responsibility of the forest landowner. He, therefore, should be protected from the fire danger caused by others, including men, women, and children from all walks of life.

Those responsible for incendiary fires are few in number, but cause more than half of all the fires, the most acreage burned, and the most damage. This situation is due to the large number of fires, plus the fact that fires deliberately and willfully set on the property of others are set at a time when and at a place where they will do the most damage and also be the most difficult to suppress. This results in widespread destruction of a major economic resource in Louisiana. Incendiarism is also a flagrant violation of property rights, and the apprehension and prosecution of those responsible, and the prevention of incendiary fires, is a public responsibility.

The intent in starting the remaining fires is entirely different. No desire to inflict damage is involved. These people start fires as a result of smoking, or for such purposes as cooking, warming, or to burn trash or brush piles. The intent is that the fire will be used for only these purposes. However, the fire escapes for reasons which come under the category of carelessness rather than deliberate intent. Laws are in effect which hold

Fire crew moves in quickly to suppress a fire before extensive damage is done.

these fire setters responsible for their acts when responsibility can be established. However, it is usually not possible to establish responsibility on an individual basis.

There are so many people involved in the smoker, camper, debris burner, and miscellaneous groups that they come under the classification of the general public. Therefore, fires resulting from the actions of people who are beyond the responsibility, influence, and control of the landowner have been charged to the general public. It appears reasonable and just that the cost of controlling fires resulting from these causes be paid from public funds.

The numbers of fires due to the above causes were tabulated by years (Table 1), and expressed as a percentage of the total number of fires (Table 2).

Who Pays for Forest Fire Protection?

Most forest landowners participating in the forest fire protection program have been paying 2 cents per acre per year since forest fire protection was started in Louisiana. Fire control expenditures of many larger landowners are considerably in excess of 2 cents per acre per year, since they also provide forest fire detection and control facilities to intensify and supplement the basic program provided by the Louisiana Forestry Commission. The remainder of the cost of fire protection comes from the general public in the form of state and federal appropriations. The forest landowner also contributes, as a taxpayer, his pro rata share of that which comes from the general public.

The amount paid by the public during the period under study varied from year to year. This payment was extremely low during the early years of fire protection in Louisiana, but increased consistently from 1933 to 1948. Since 1948 there have been slight increases and decreases per acre from year to year, with an upward trend of less than 1 per cent per year.

Comparison of Landowner-Caused Fires with Protection Payments Made by Landowner

Forest landowners were responsible for 10,824 of the 133,515 fires, which amounts to only 8 per cent of the fires on protected acres from 1933 to 1961. The forest landowner thus has been responsible for only one out of every 12 fires which damaged his property. Yet these forest landowners have paid more than their share of the fire protection costs each year since 1933. This overpayment was tremendous during the early years of forest fire protection, ranging from a high of over 13 times what the records show it should have been in 1935, to a low of 3 per cent overpayment in 1961. The forest landowner is currently paying for slightly more, and the public for slightly less fires than fall within their respective responsibilities. These data are recorded in Table 1 and Table 2, and are shown graphically in Figure 1.

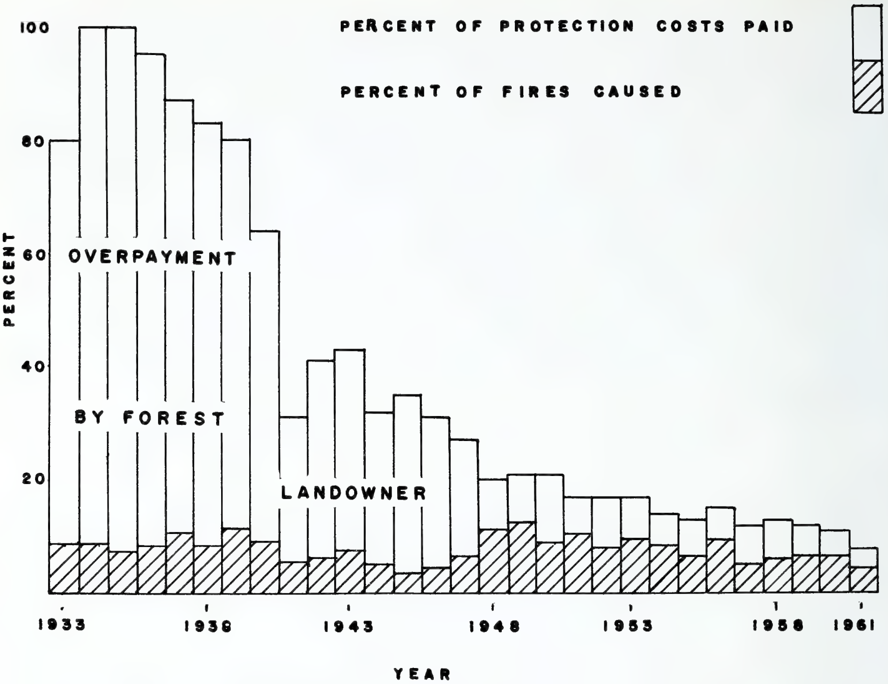

FIGURE 1.—Forest landowner record on fire protection, 1933 to 1961.

Comparison of Public-Caused Fires with Protection Payments Made by Public

Someone other than the owner caused 122,691 (or 92 per cent) of the 133,515 fires which burned on protected acres from 1933 to 1961. Thus 11 of every 12 fires which burned the forest landowners' property were caused by people in all types of activities and can be best classified as the responsibility of the general public.

A study of the records reveals that the public has been slow in recognizing its responsibility for forest fires and hesitant in the past to accept its responsibility in supporting forest fire prevention and control (Figure 2). The greatest disparity was during the 1930's, when the public was causing 90 per cent of the fires while paying for only 11 per cent of the cost of forest fire protection. Additional public support for forest fire protection was given during the 1940's, and by 1948 the contribution to the cost of forest fire protection was approaching a balance with the percentage of fires caused by the general public.

However, as in the past, the public continues to cause more forest fires than it is paying to prevent or control. This underpayment on the part of the public has been small since 1948. During this period, the forest landowner has been paying for slightly more and the public for slightly fewer fires than fall within their respective responsibilities.

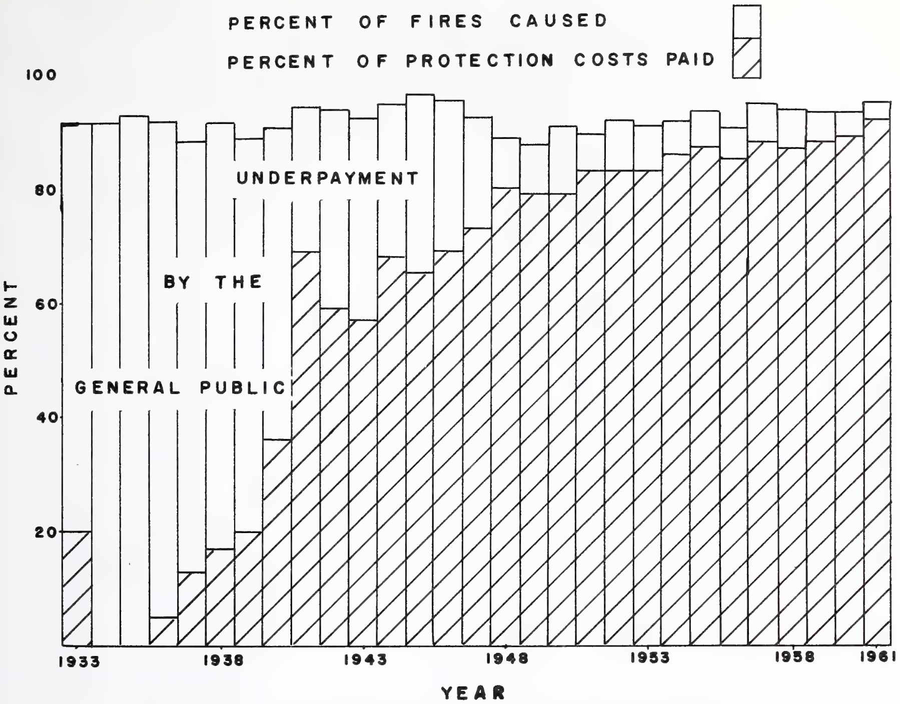

FIGURE 2.—Public record on fire protection, 1933 to 1961.

The prospects for the future are for a smaller number of fires caused by the landowners and more fires caused by people who are best classified as the general public. This is due to the fact that there is a slow decrease in the number of landowners, and a rapid increase in the number of picnickers, campers, hunters, fishermen, and other people who use the forests for recreation. Since over 99 per cent of all forest fires in Louisiana are caused by people, any increase in the number of people in the forests increases the risk of fire.

Benefits from Productive Forests

Many benefits are derived from Louisiana forests, and all of these benefits may be heavily damaged or completely destroyed by fire. It is, therefore, necessary that timber and associated resources be protected from fire so they may continue to serve as an important part of the state's present and future economy. The interest of the various phases of the economy in forest fire protection is in direct proportion to the benefits received from forests which have not been damaged or destroyed by fire. The recipients of benefits should also participate in the costs of a basic forest fire protection program in proportion to the benefits received.

What benefits come from productive forests and who gets them? Do these benefits go mostly to the landowner, or do they spill over to include others, and to what extent? These questions also relate to the assignment of responsibility for the payment of forest fire protection.

Benefits derived from productive forests include wood, water, recreation, wildlife, forage, and soil stabilization. Some of these are tangible and can be expressed in monetary terms. Others are intangible and cannot be expressed in terms of money. Even though some benefits cannot be expressed in dollars and cents, the importance of protecting them cannot be overlooked. Recreation, wildlife, water, and soil stabilization are such benefits.

The only benefits of Louisiana forests which can readily be expressed in terms of dollars are wood products. Therefore, the value of wood products to the landowner and to others was determined. Records of the Louisiana Tax Commission and the Louisiana Forestry Commission were searched for data that would provide suitable information for a period of years. The 14-year period from 1947 to 1960 was selected, since the data were current and reliable (Table 3 and Figure 3). The landowner's share was determined by using the stumpage values established jointly each year by the two agencies mentioned above for severance tax purposes. The total value of timber cut and processed in Louisiana was obtained from the "Industrial Development and Manufacturers Record, Blue Book of Southern Progress," which is published annually. Data obtained from the "Blue Book of Southern Progress" and summarized here do not include some of the smaller timber-based industries and are, therfore, felt to be conservative.

The value of manufactured products derived from Louisiana forests during the 14-year period was $7,789,200,000 (Table 3). The forest landowner, who grew the raw material, received $280,273,000 for stumpage, or

TABLE 3.—Stumpage Value and Total Output Value of Timber Products Cut from Louisiana Forests, 1947 to 1960

Year	Stumpage[1] value ($ Million)	Output[2] value ($ Million)	Year	Stumpage value ($ Million)	Output value ($ Million)
1947	14.300	401	1955	18.700	551
1948	18.080	516.5	1956	19.710	506
1949	15.489	424.7	1957	21.060	720
1950	18.779	463	1958	19.847	627
1951	25.125	506	1959	23.158	756
1952	22.605	582	1960	22.837	760
1953	20.507	494	Total	280.273	7,789.2
1954	20.076	482	Avg.	20.019	556.37

[1] Computations are based on timber severance tax data and stumpage values provided by Louisiana Tax Commission and Louisiana Forestry Commission and rounded off to the nearest $1,000. This is the value received by timber growers as stumpage.

[2] Values for pulp and paper, lumber, and furniture manufacturing, as reported in "Industrial Development and Manufacturers' Record, Blue Book of Southern Progress." The figures represent the total values for stumpage, harvesting, and processing of trees through the final stages for these three major manufacturing divisions.

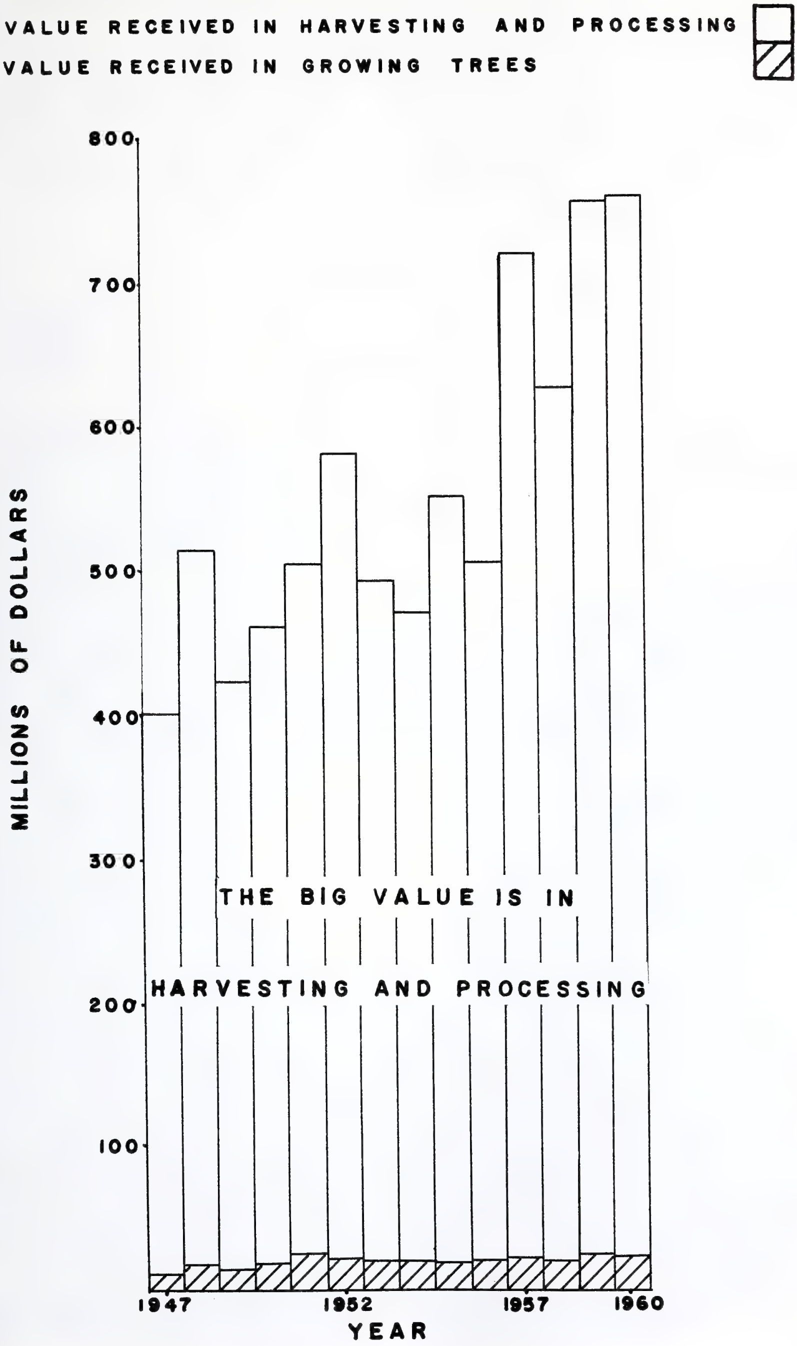

FIGURE 3.—Value received from growing trees compared with value received from harvesting and processing trees in Louisiana, 1947 to 1960.

less than 4 per cent of the total value; others received $7,508,927,000, or over 96 per cent of the total value of the wood products. In other words, every time the forest landowner received $1 for stumpage, other people received $26.79 for felling, limbing, bucking, skidding, loading, hauling, manufacturing, drying, selling, shipping, and using that dollar's worth of stumpage. This means the value of timber to the state's economy increased nearly 27 times between stump and finished product. The activities which brought about this increase resulted in employment of from 20 to 35 per cent of all industrial workers in the state during this period.

Lookout towers such as this one are key components in fire detection and control systems.

Recreational activities include hunting, fishing, camping, sight-seeing, and picnicking. Most people participate in at least some of these activities whether or not they own forest land, and these activities fall into the category of benefits to the general public. Most of the surface water of the state flows across parish boundaries, and thereby becomes a state responsibility. The soil- and water-conserving characteristics of forests do not merely benefit the owner, who is practicing forest conservation, but are of primary benefit to people downstream where flooding and siltation would occur if it were not for forested watersheds upstream. Everyone who desires to be protected from floods, who uses water, and who depends upon the soil for a source of food, clothing, and shelter, benefits from these important values. They are of great importance to the general public, and the responsibility for their protection should fall upon the various governments to the extent that these governments and the people therein benefit from these services.

Summary and Conclusions

This study deals with the broad criteria of who causes forest fires and who benefits from productive forests. Highlights of the findings are as follows:

1. The analysis of data in an effort to divide the responsibility for forest fires between the forest landowner and the public revealed that the forest landowner was responsible for 8 per cent and the public for 92 per cent of the fires that burned the forest landowner's property during the 29-year period from 1933 to 1961.
2. A study to determine the benefits received from timber showed that the landowner received less than 4 per cent and the public received over 96 per cent of the total value of timber products during the 14-year period from 1947 to 1960.
3. An approximate assignment of interest in, and responsibility for, forest fires may be obtained by combining the results of the two areas of study and giving equal weight to each. This gives the forest landowner approximately 6 per cent and the public approximately 94 per cent interest in, and responsibility for, forest fire prevention and control.
4. Forage, wildlife, recreation, and water were recognized as important products of the forests, but their values were not expressed in dollars because of the difficulty of making a realistic appraisal with the present state of knowledge.
5. The study revealed that forest landowners of Louisiana have paid more than their share of the costs each year since forest fire protection has been in existence. This overpayment was tremendous during the early years of forest fire protection, and varied from a high in 1935 of over 18 times what this study found it should have been, to a low of about 3 per cent overpayment in 1961. The forest landowner is currently paying for slightly more, and the public for slightly less, fires than fall within their respective responsibilities.

6. The current landowner-public ratio of financing forest fire protection is so nearly in balance that no justification was found for strong support of either an increase or decrease in the forest acreage tax now paid by the forest landowner. A significant change would be required for it to be important as a revenue measure. An increase would impose an inequity on the forest landowner, and a significant decrease would be unfair to the public.

7. A change in the amount of the forest fire protection tax should be considered when total expenditures, and the causes of forest fires, change to such an extent that payments made by forest landowners and the public get significantly out of balance with their responsibilities. A need for such a change is not anticipated for a number of years, unless fire control expenditures and causes of forest fires change more rapidly in the future than they have in the past.

8. Most forest fires (11 out of 12) in Louisiana are caused by the actions of people other than the owner and are a public responsibility. The cost of protecting the forest landowner from these fires should be assumed by the various governments (local, state, and federal) to the extent that the people therein contribute to forest fires and benefit from productive forests.

9. Incendiary fires occur more frequently in Louisiana than forest fires of any other type. These are fires deliberately set by people on the property of others when burning conditions are critical. They represent the most destructive fires.

10. The most important economic values of productive forests are created through harvesting, manufacture, and sale of wood products, rather than by the growing of trees. Less than 4 per cent of the total value of wood products is received by landowners in the sale of stumpage; other persons receive over 96 per cent of the total value of wood products. This means that when the forest landowner received $1 for stumpage, other people received $26.79 from harvesting, manufacturing, marketing and using that dollar's worth of stumpage under average conditions that prevailed in Louisiana from 1947 to 1960.

It follows that the public interest is best served with a tax structure that creates favorable conditions for good forest management, which results in high timber yields. This in turn permits timber products to be continually placed into the channels of trade. This process makes it possible for productive forest land to make its maximum contribution through jobs, payrolls, and business activity created by the process of harvesting, manufacturing, marketing, and using timber. Productive forests also contribute to soil stabilization, water conservation, wildlife habitat, and recreation, whereas unproductive forests make only minimum contributions. Therefore, the taxing system on timber resources which will yield the greatest returns to the greatest number of people is one which encourages the forest landowner to maintain his timberland in a state of high productivity. The most productive tax base consists of business, recreational, and conservation values which come from productive forests. This portion of the tax base is lost if the forests are unproductive. The real problem in forest taxation is to develop a proper blend of the several taxes paid by the forest landowner, so that he contributes his fair share toward the total tax burden, without discouraging the maintenance of the productive capacity of the forests on a continuous basis.

11. This study applies to past and present situations, and should serve as a guide for the future. It was made in Louisiana and applies to this state. However, the methods used here could be applied in other states where adequate records are available.

Fire-blackened trees mark not only a loss of timber, but also loss of the many other benefits derived from productive forests.

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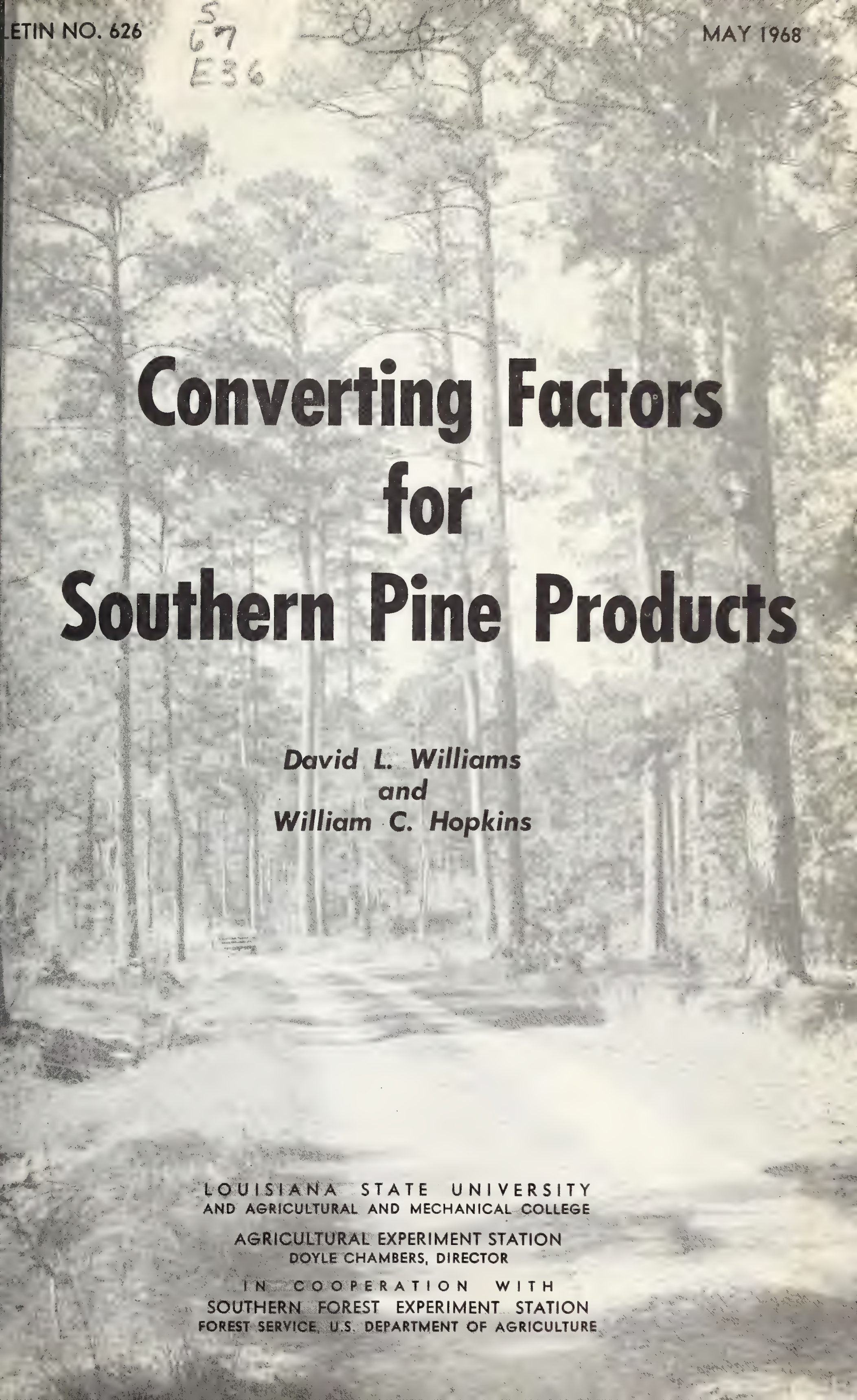

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Converting Factors for Southern Pine Products

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SUMMARY

The objective of this study was to provide a usable manual for converting measures of southern pine wood products from one unit to another. Converting factors were determined for the following relationships: cord volume measurements, board foot-log scale relationships, cubic measure information, lumber yields for log grades, weight factors, veneer and plywood factors, pulp utilization factors, factors for poles and piling, wood residue factors, and factors for minor forest products of the southern pine species. Variations due to differences in species, geographical area, and utilization practices are shown whenever possible.

Over 300 published references pertaining to converting factors for southern pine products were reviewed. Descriptive abstracts containing numerical data were then prepared and filed by subject. Abstracts from pertinent citations were analyzed for their contribution and applicability to current scaling procedures and utilization methods.

Supplementary data were obtained from reliable industrial sources by correspondence and by personal contact. Twenty-one firms throughout the southern United States contributed, on a confidential basis, information in the form of production data, office reports, and results from private research projects.

Converting factors were developed for each major topic and are presented in tabular and summary form. It was found that conversions applying in one situation did not apply exactly in another because of divergence in methods, equipment, or raw materials. Therefore conditions under which each factor can be used are stated whenever possible.

Converting Factors for Southern Pine Products

David L. Williams and William C. Hopkins*

INTRODUCTION

Conversion factors applicable to the manufacture of certain southern pine products have been determined by numerous investigators. However, a thorough search of the published material failed to reveal any conveniently consolidated and documented digest of these factors. The objective of this study, therefore, is to publish a concise, usable manual of factors, applicable to the southern pine species, for converting from one unit of measurement to another.

The principal method of investigation in this study has been to carefully analyze and abstract pertinent published references and then to compile by subject, in the form of tables and charts, conversions from one unit of measure to another of forest materials.

Conversion factors that are accurate in one situation may not apply exactly in another because of divergence in methods, equipment, or raw materials. Thus, when possible, consideration was given to geographical variations in utilization practices and in species.

Wood products are sold in a number of different units. Initially, each piece is scaled either separately or in bulk quantities depending upon the proposed product, which in turn is determined by the size, shape, form, and, in some cases, species of raw material. Forest products may be measured in board feet or cubic feet, or cord or weight measures may be applied for materials scaled in bulk quantities. Raw materials may also be sold by the piece in the form of ties, posts, poles, and piling. The volume of these raw materials is comparatively easy to determine from the specifications of the desired product. When logs are sold in the round, however, volumes of individual logs must be computed from the actual measurements.

One acceptable form of cubic foot measure is to convert cubic feet into cords by a suitable converting factor that is agreeable to the parties concerned. Cubic scales are the most accurate volume measures in common use because they measure the actual solid wood content of a log. However, these units do not allow for saw kerf, slabs, edgings, shrinkage, or sawing methods.

Log scales are used to enable one to estimate the number of board feet in logs of different sizes. A log scale shows the amount of a product that can be recovered from logs of different sizes under assumed conditions. Log scales are estimates of the gross and/or merchantable volume of a log. Additional measurements may be taken during the initial scaling to calculate the volume of alternative products that may be recovered. Such comprehensive measurements can result from a program of log segregation, whereby logs are separated into utilization channels that will yield the highest use value per piece. Thus, scaling is not a guess; it is a scientific estimate based on certain fundamental rules and tempered with experience.

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*Former Graduate Student and Professor (now deceased), respectively, School of Forestry and Wildlife Management.

The traditional unit of measure for pulpwood has been the cord. Cord measure normally applies to sticks of smaller diameter than those used for the production of lumber. In addition to providing the basic pulpwood measure, cord volume has been applied to bulk measures of bark, chips, sawdust, and other sawmill residues.

The ratio of weight to standard units of measure varies considerably, and no fixed converting factors can be universally applied with any reasonable degree of accuracy. Local factors and ratios for weight-volume relations must be computed. Weight-volume ratios for logs and bolts are influenced by the moisture content of the wood, the diameter, the wood density, the amount and type of rot present, the accumulation of pitch, and the bark characteristics.

Piece-products must meet certain specifications for each class and grade of product. Linear measure is used for items such as poles and piling, where length and strength are far more important than volume alone.

The preceding discussion enumerates the apparent differences in types of measurement units and in the application of these units to quantities of forest products. The remainder of this study is devoted to consideration of existing combinations among units and the practicality of standardized computations.

Definitions of Terms and Abbreviations

The following definitions and terms are used throughout the manuscript and may need clarification:

1. Green wood or bark: Wood or bark with a moisture content of approximately 50 percent or more. Many firms do not specify the precise moisture content of their raw material or waste, but categorize them as green or dry.
2. Green weight: Weight of freshly cut or standing timber.
3. Scaling diameter: The diameter, inside bark, at the small end of the log, unless otherwise specified.
4. Mid-diameter: The diameter, outside bark, at a point that is intermediate between the two ends of the log or bolt.
5. Standard cord: A pile of stacked wood occupying 128 gross cubic feet of space.
6. Rough cord or rough volume: The volume of both wood and bark.
7. Piece-product: Any of several forest products that must be scaled individually and then classed according to some predetermined specification.
8. Product-mix: The manufacture of various products under a given set of market conditions to fulfill an immediate objective.

The following abbreviations are used consistently in table headings throughout the manuscript:

Avg.	Average	Ht.	Height
Cds.	Cords	Lbs.	Pounds
Cu. Ft.	Cubic feet	MBF	Thousand board feet
Dbh	Diameter breast high	M sq. ft.	Thousand square feet
Dia	Diameter	M lbs.	Thousand pounds
Dib	Diameter inside bark	Pct.	Percent
Dob	Diameter outside bark		

PROCEDURE

Data Collection

Data were collected by library research, by correspondence, and through personal interview to obtain all information, published and unpublished, pertinent to the subject of converting factors for southern pine products.

Converting factors were determined for the following fundamental relationships:

1. Cord volume measurements
2. Board foot-log scale ratios
3. Cubic measure
4. Log and lumber scale information
5. Weight-volume measurements
6. Utilization methods for pulp and paper mills
7. Utilization methods for plywood mills
8. Production of poles and piling
9. Wood residue factors
10. Minor forest products

Library Research

Subject matter was obtained from the libraries of the Louisiana State University and the U.S. Forest Service, from state forestry organizations, forestry schools, journal articles, and private firms. After each publication or study was reviewed, an abstract was prepared and filed according to the subject content. Information from these abstracts was then analyzed and compiled in the form of tables and charts, and conversion factors were computed. Hopefully, the study would reveal variations existing among sources of information, geographical areas, species, and utilization methods.

A comprehensive bibliography was prepared to allow for future revision of the proposed publication to include current utilization methods.

Direct Correspondence

Correspondence and personal interviews supplemented the information gained from published library materials. Questionnaires were mailed to the woodlands division of every southern pulp and paper manufacturer and to every sawmill in the South producing annually at least three million board feet of pine lumber. Firms were asked to release any information they had collected through production research concerning the measurement of forest products.

Firms that were willing to cooperate in the research and could furnish the desired information were asked to include, whenever possible, the source of the raw material, its moisture content, and specific gravity. It was anticipated that, for the most part, industrial firms did not differentiate among species at conversion centers. However, all available possibilities were examined.

Personal Interview

During the summer of 1966 the senior author had the opportunity to travel extensively throughout the South to visit the cooperating firms. Many unpublished studies, office reports, and confidential converting factors, which would have been otherwise inaccessible, were thus obtained.

Through personal conferences with research and woodlands personnel, the senior author gained insight into the measurement and conversion problems facing the southern pine industry. He found, in his evaluation of the private research being conducted and in the personal views expressed by members of the industry, a need for standard conversion factors throughout the southern region.

Converting factors to be developed for any specific product were limited only by the allotted time, by the availability of data, and by the authors' experience. Because of the critical time element involved and the enormous quantity of literature relating to the subject in question, no time was allotted to actual field measurements even though information currently available is inadequate in some areas.

RESULTS AND ANALYSIS

The library research revealed that there are drastic differences in the units used to describe quantities of raw materials from the forest. One scale may be used for managing and cruising timber, while others are often encountered in the marketing process. Standing timber is normally referred to in units of board feet, but harvested logs may be measured by the cubic, cord, or board foot volume, or in units of weight measure.

Initially, each piece is scaled separately or in bulk quantities depending upon the proposed product, which in turn is determined by the size, shape, form, and sometimes species.

Information was obtained on a confidential basis by personal contact from 21 firms throughout the southern pine region. Others provided reliable data via the questionnaire, thus contributing materially to the wealth of information collected. In almost every instance, firms indicated a desire for a standard unit of volume measure throughout the industry.

Each major converting factor topic is treated separately in the following analysis. Information from published sources and industrial firms is reviewed, and converting factors that were developed are presented in tabular and in summary form. Sources for values that are quoted directly from published material are cited in table footnotes.

Cord Volume Factors

Cubic Feet of Solid Wood, Bark, and Air Space per Cord

The standard unit of measure for stacked wood is the cord. The standard cord occupies 128 gross cubic feet of space. Ordinarily this is a rick piled 4 feet high, 4 feet wide, and 8 feet long; however, a rick of any dimension that contains 128 cubic feet of wood, bark, and air space is considered to be the standard cord. Air space in a stacked cord may range from 14 to 40 percent, and a working average is 25 percent for southern pine. For southern pine operations, the average cubic feet of solid wood per cord ranges from 56 to 94 (Table 1). The working average for green, unpeeled wood is 76 for loblolly pine and 85 for longleaf pine. These values may be used in the absence of a local converting factor.

Van Sickle (1966) showed that larger timber is now being used for pulpwood than was being used in 1950, resulting in a higher solid wood content per standard cord. His results, also showing a regional variation in solid volume per cord, are summarized in Table 2. The percentage of stacked space in a standard cord that is occupied by solid wood is shown in Figure 1 as a quadratic function of average bolt diameter (MacKinney and Chaiken, 1939). These values are somewhat lower than present values and reflect former trends in pulpwood production.

Measurements of 50,000 cords by one southern pine mill showed 76.7 cubic feet of wood, 16.2 cubic feet of bark, and 35.2 cubic feet of air space.

The quantity of solid wood in a cord is influenced by the diameter, length, and form of the individual bolts, the bark thickness, and the method of piling and shipping.

Diameter, Form, and Position—A stacked cord of small-diameter bolts has less solid wood than one of large-diameter bolts. The larger bolts are straighter and smoother because they tend to come from lower bole positions and are

TABLE 1.—Volume of solid wood in a standard rough cord of 4-foot bolts according to species, bolt characteristics, and mid-diameter outside bark[1]

Character of bolts	Mid-diameter less than 6 in.		Mid-diameter 6-12 in.		Mid-diameter greater than 12 in.	
	LL[2]	Lob[3]	LL	Lob	LL	Lob
	Cubic feet					
Straight						
Smooth	84	76	89	80	94	84
Slightly rough	81	74	87	78	92	83
Slightly rough and knotty	79	71	85[4]	76[4]	90	81
Not Straight						
Slightly crooked and rough	75	67	83	74	87	78
Very crooked	71	64	80	71	84	76
Crooked, rough and knotty	66	58	74	66	78	70
Tops and branches	63	56	--	--	--	--

[1] Data adapted from U.S. Forest Service, Lake States Forest Experiment Station, 1935, (Mimeo.), Forest Research Digest. Original data, based on spruce, were reduced proportionally for the southern pine species, which have less uniform bolt characteristics.

[2] Longleaf pine.

[3] Loblolly pine.

[4] Working averages for longleaf and loblolly pine.

TABLE 2.—Volume of solid wood per standard cord of pulpwood by species and location

Region	Year	All species	Pine	Hardwood
		Cubic feet		
Midsouth	1950	--	75	78
Midsouth[1]	1965	81	81	80
East Gulf	1964	80	80	79
West Gulf	1965	82	82	81

[1] East and West Gulf factors are combined in proportion to annual pulpwood production.

Source: Van Sickle, Charles O. 1966. Factors for converting mid-south pulpwood from cords to cubic feet. U.S. Forest Serv. Res. Note SO-45.

free of trimmed branches and protruding knots. The increase in surface quality of bolts from butt logs offsets the disadvantage of thicker bark that is often associated with lower bole positions.

A stacked cord of wood cut from open-grown, limby trees has less solid content than wood from well-pruned trees, and a cord of tops and branches has less solid content than one of bole or stem wood (Forbes and Meyer, 1955). Rough cords of loblolly from thinnings contained 82 cubic feet of solid wood, whereas rough cords from mixed tops and thinnings contained 74 cubic feet per cord.

The usual minimum diameter at the small end of pulpwood sticks is 3.5 inches, inside bark. Although some mills frequently process bolts up to 30

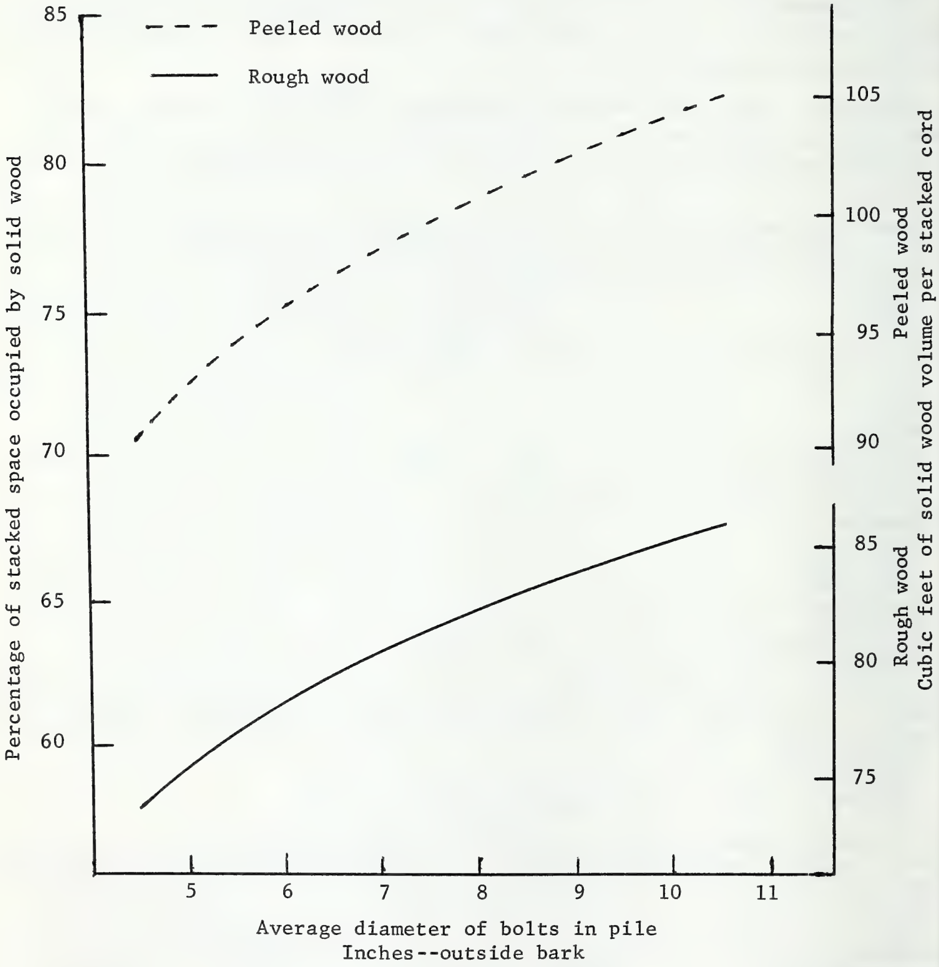

FIGURE 1.—Converting factors for loblolly pine pulpwood showing the percentage of stacked space occupied by solid wood (exclusive of bark) in piles having different average bolt diameters; for rough and peeled wood. (Adapted from MacKinney, A. L., and L. E. Chaiken. 1939. Volume, yield, and growth of loblolly pine in the Mid-Atlantic coastal region. U.S. Forest Serv., Appal. Forest Exp. Sta., Tech. Note 33.)

inches in diameter, the average maximum diameter for southern pine pulpwood is 22 inches.

Length—A stacked cord of long sticks has less solid wood than one of short sticks. Piled 5-foot pulpwood bolts contain about 1½ percent less solid wood per cord than the same timber cut to 4-foot lengths and piled.

Kraft mills in the Southeast generally specify 63-inch bolt lengths, whereas Appalachian mills and mills west of the Mississippi specify 60-inch wood. In general, groundwood mills specify 48-inch wood.

TABLE 3.—Weight and volume equivalents for loblolly pine pulpwood by diameter class

Dimensions of avg. pine tree			Weight[3] per		Stacked volume occupied[4]	Trees per unit[5]	Rough volume per unit[5]
Dbh	Ht.[1]	Vol.[2]	Cu. Ft.	Tree			
In.	Ft.	Cu. Ft.	Lbs.	Lbs.	Pct.	No.	Cu. Ft.
4	30	0.6	66.4	40	58.0	162	97
	38	1.2	66.0	79	59.3	83	99
6	45	2.5	65.6	164	60.5	41	101
	51	4.3	65.3	281	61.7	24	103
8	56	6.5	64.9	422	62.7	16	105
	62	9.4	64.6	607	63.7	11	107
10	67	12.8	64.4	824	64.6	8	108
	71	16.7	64.3	1074	65.5	7	110
12	75	21.1	64.2	1355	66.2	5	111
	78	26.1	64.1	1673	66.8	4	112
14	82	31.8	64.0	2035	67.4	4	113

[1] Average merchantable height.
[2] Merchantable to 4-inch outside-bark top (wood only).
[3] Adapted from industrial research.
[4] Volume of wood and bark as a percent of gross stacked volume.
[5] **168 cubic foot unit; 5¼ × 4 × 8 ft. stack of rough wood.**

Source: Wahlenberg, W.G. 1960. Loblolly pine. Duke University. School of Forestry, Durham, N.C. Courtesy, Duke University, School of Forestry.

TABLE 4.—Volume and weight factors for stacked standard cords of 4-foot longleaf pine pulpwood[1]

Mid-diameter of avg. bolt, i.b.	Bolts per cord	Volume per cord		Average green weight per cord[2]
		Solid wood	Bark	
In.	No.	Cu. Ft.	Cu. Ft.	Lbs.
5	128.0	56.2	23.1	4837.3
6	97.0	63.2	23.1	5264.3
7	64.0	67.2	22.0	5429.0
8	51.2	69.8	21.2	5551.0
9	41.3	70.9	20.7	5587.6
10	33.7	73.9	20.7	5770.6
11	28.5	74.2	20.3	5764.5
12	24.1	75.3	19.5	5782.8
13	20.6	77.0	19.6	5892.6
14	17.8	78.2	20.0	5990.2
15	15.6	80.0	20.0	6100.0
16	13.7	83.2	20.5	6325.7

[1] **Based on measurements of 133 pine stems, scaled at one pulp mill in the Southeast.**
[2] Weights given are based on a green weight of 61 pounds per cubic foot of solid wood and bark.

TABLE 5.—Cubic foot contents of pulpwood units

Unit dimensions			Gross volume occupied	Volume of solid wood and bark
Bolt length	Stack height	Stack length		
Ft.	Ft.	Ft.	Cu. Ft.	Cu. Ft.
5	3.2	8	128	86
4	4	8	128	90
4	4.5	8	144	101
4	5	8	160	113
4	5.25	8	168	118
4	6	8	192	135
4	8	8	256	180
4	8.33	8	275	181[1]
4.5	5	8	180	126[1]

[1] International Harvester. (N.D.) Handbook of Log Rules. 31 p.

Source: U.S. Forest Service, 1965. Service foresters handbook. Division of State and Private Forestry, Atlanta.

TABLE 6.—Board feet per standard cord in pine timber by dbh class

Dbh	Doyle	Scribner
In.	Bd. Ft./Cd.	Bd. Ft./Cd.
10	107	219
12	166	283
14	218	327
16	264	360
18	301	383
20	327	395
22	351	406
24	374	317
26	394	428
28	413	439

Source: Forest Farmers Association. 1966. Forest Farmer Manual. 25(7):141-143.

TABLE 7.—Trees per cord and cords per thousand board feet

Dbh	Trees per cord[1]	Standard cords per thousand board feet		
		International ¼	Scribner	Doyle
In.	No.	Cords		
5	46	--	--	--
6	21	--	--	--
7	15	--	--	--
8	10	4.0	4.4	6.8
9	8	3.7	4.1	6.8
10	6	3.4	3.8	6.8
11	5	3.2	3.6	6.3
12	4	2.9	3.4	6.2
13	-	2.7	3.2	5.2
14	-	2.5	3.0	4.5

[1] Approximation for rough determination.

Source: U.S. Forest Service, 1965. Service foresters handbook, Division of State and Privat Forestry, Atlanta.

Bark—A cord of peeled wood contains 7 to 18 percent more solid wood than a rough cord. A working average of 11 percent of the gross stacked volume is suitable for southern pine operations.

Chamberlain and Meyer (1950) developed a regression to predict the percent of bark volume in a stacked cord of pulpwood. Bark volume (in percent) = 80 ($1\text{-}k^2$) . . . where k = the average ratio of diameter inside bark to diameter outside bark. Measurements on 20 to 30 bolts for a given species and locality are necessary to establish the "k" value.

Species—Longleaf pine has superior bole form and contains a greater amount of solid wood substance per cord than other southern pine species of the same diameter. Cord for cord, however, the difference in species is of little significance because no provisions are made for this variance at scaling points. The abundance of and the larger average diameter of loblolly and shortleaf pine bolts offset the advantage of using the more cylindrical longleaf pine.

Piling and Shipping—Most studies conducted throughout the industry show significant differences among percent solids per cord due to methods of

TABLE 8.—Number of pulpwood bolts[1] of various lengths per standard cord

Mid-diameter of avg. bolt, i.b.	Bolt length in feet				
	4	5	5.25	5.66	6
In.	Number of bolts				
5	152	122	116	108	102
6	109	87	84	78	73
7	82	66	62	58	55
8	64	51	49	45	43
9	51	41	39	36	34
10	42	33	32	30	28
11	35	28	27	25	23
12	30	24	23	21	20

[1] Bolts have better than average form and surface quality.

Source: Hawes, E. T. 1940. Volume tables, converting factors, and other information applicable to commercial timber in the South. 3rd. Ed., U.S. Forest Serv., Div. of State and Private Forestry, Atlanta.

TABLE 9.—Number of veneer cores per standard cord[1]

Core diameter	Core length in inches	
	102[2]	54[3]
In.	Cores per cord	
3.5	191	402
4.0	148	312
4.5	117	245
5.0	93	196
5.5	78	163
6.0	64	135
6.5	55	116

[1] Calculations based on volumes of true cylinders.

[2] Cross-sectional dimensions of the cord consisting of 102-inch cores are 48 inches by 48 inches.

[3] Cross-sectional dimensions for the cord consisting of 54-inch cores are 48 inches by 96 inches.

stacking, transportation, and scaling practices. Small-scale harvesting operations produced more uniform and efficient stacks of bolts. Stacking by hand results in higher percent solids per cord and in greater weight per cord than when the wood is stacked by mechanical means.

One southeastern mill reported that settling during transportation resulted in a greater volume and weight per cord when pulpwood was rescaled at receiving points. In the same operation, railwood settled more than truckwood (Figure 2). Values were derived as industry averages from southern Alabama and southwestern Georgia. As average bolt diameter increases above 9 inches, the loblolly-shortleaf pine species group gradually overtakes the longleaf-slash pine group, resulting in a greater solid wood content per unit of stacked volume for the loblolly-shortleaf pine group.

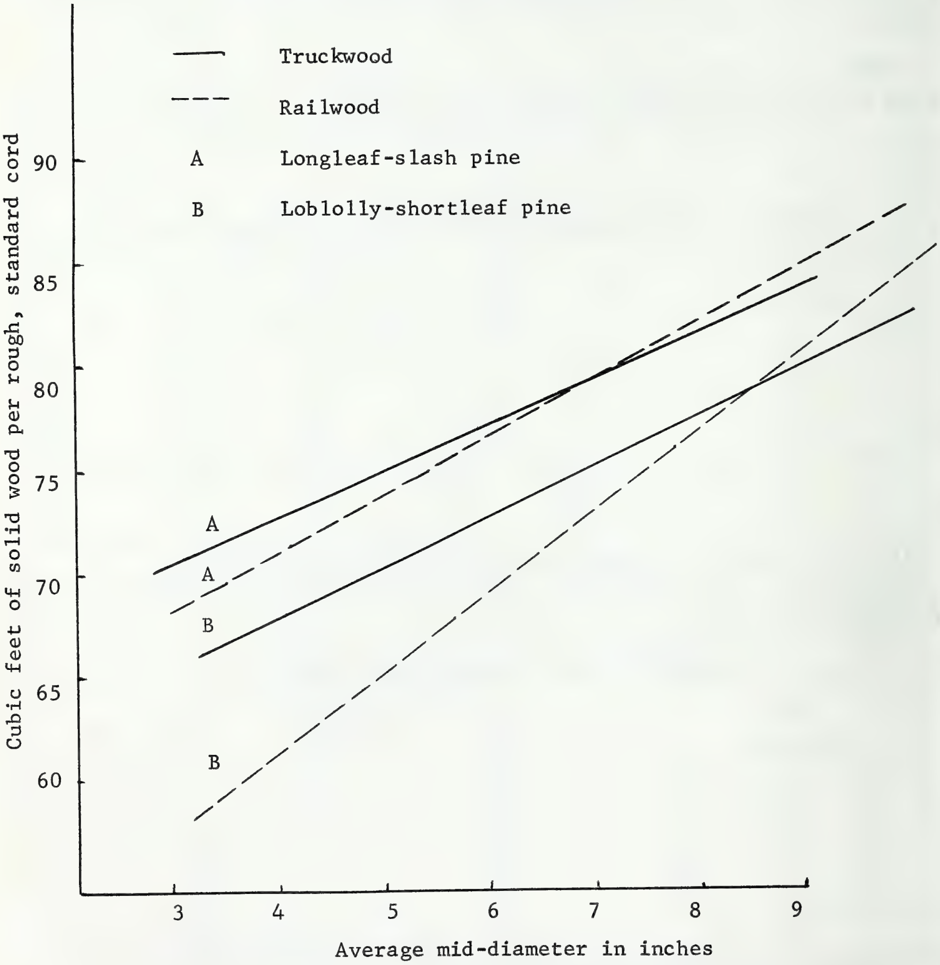

FIGURE 2.—Solid wood volume per cord compared to average mid-diameter of southern pine pulpwood bolts for two hauling methods. (Based on data collected by the woodlands division of one southern pine pulp and paper manufacturer.)

TABLE 10.—Number of trees per standard cord for southern pine

	Tree height in number of 5-foot 3-inch bolts[1]										
Dbh	2	3	4	5	6	7	8	9	10	11	12
In.	Trees per cord										
5	69.4	49.3	38.3								
6	48.8	36.1	28.7	23.8							
7	36.9	27.9	22.4	18.7	16.1	14.1					
8		22.2	18.0	15.1	13.0	11.4	10.2	9.16	8.34		
9		18.2	14.7	12.4	10.7	9.40	8.38	7.56	6.89	6.33	5.85
10			12.3	10.4	8.95	7.87	7.02	6.34	5.77	5.30	4.90
11			10.5	8.82	7.60	6.68	5.96	5.38	4.90	4.50	4.16
12			9.03	7.58	6.53	5.74	5.12	4.61	4.21	3.86	3.57
13			7.86	6.59	5.67	4.98	4.44	4.00	3.64	3.35	3.09
14			6.90	5.78	4.97	4.36	3.88	3.50	3.19	2.92	2.70
15						3.85	3.43	3.09	2.81	2.58	2.38
16						3.42	3.04	2.74	2.49	2.29	2.11

[1] Merchantable height to 4-inch top outside bark.
Source: Forest Farmers Association. 1966. Forest Farmer Manual. 25(7): 141-143.

TABLE 11.—Number of 5-foot bolts per tree by dbh and total tree height[1]

	Total tree height in feet								
Dbh	20	30	40	50	60	70	80	90	100
In.	Number of bolts								
5	1.5	2.1	2.9	3.5	4.2	4.9	5.8		
6	2.0	2.9	3.9	4.6	5.6	6.6	7.5		
7	2.2	3.4	4.5	5.6	6.9	8.5	9.4	10.3	
8	2.3	3.8	5.0	6.4	7.7	9.6	10.7	11.6	
9	2.3	4.1	5.3	6.9	8.3	10.4	11.6	12.3	
10		4.3	5.5	7.2	8.8	10.9	12.3	12.8	
11		4.4	5.7	7.4	9.2	11.3	12.6	13.2	14.4
12		4.5	5.9	7.6	9.5	11.6	12.9	13.5	14.7
13		4.5	6.0	7.6	9.7	11.8	13.1	13.8	15.0
14		4.5	6.1	7.7	9.8	11.9	13.3	14.0	15.3
15			6.2	7.7	9.9	12.0	13.4	14.2	15.5
16			6.2	7.8	9.9	12.0	13.5	14.4	15.6
17			6.3	7.8	10.0	12.1	13.6	14.5	15.6
18				7.8	10.0	12.1	13.7	14.6	15.7
19				7.9	10.0	12.2	13.8	14.6	15.7
20				7.9	10.1	12.2	13.8	14.7	15.7

[1] Average number of 5-foot pulpwood bolts which can be cut from loblolly pine trees above a stump of 0.7 foot to a merchantable top of 4.0 inches outside bark.

Source: MacKinney, A. L., and L. E. Chaiken. 1939. Volume, yield, and growth of loblolly pine in the Mid-Atlantic coastal region. U.S. Forest Serv., Appalachian Forest Exp. Sta., Tech. Note 33.

TABLE 12.—Factors for converting basal area to cord volume

Avg. total tree height	Volume per square foot of basal area
Feet	Rough cords
30	0.14
40	0.18
50	0.24
60	0.30
70	0.34
80	0.37

Source: Minor, Charles O. 1953a. Converting basal area to pulpwood volume. La. Agr. Exp. Sta., LSU Forestry Note 3.

Nonstandard Cords

Some pulpwood buyers use nonstandard cords in purchasing although they retain the use of the word "cord." Some of these nonstandard cords used in the South are:

1. The 160-cubic foot cord, which consists of 5-foot bolts piled 4 feet high and 8 feet long. This unit of measure is sometimes referred to as the "long" cord.
2. The 168-cubic foot cord, or "unit," consists of 5-foot 3-inch bolts piled 4 feet high and 8 feet long. According to the Forest Farmers Association (1966), 1 unit = 1.315 standard cords.
3. The 200-cubic foot unit is the gross stacking density of straw-piled pulpwood bolts 5 feet 3 inches long.
4. The pen is a pile of wood 6 feet high, consisting of two sticks to a layer, each layer at right angles to the one beneath. Five pens of 4-foot bolts equal 1 standard cord, or 5 pens of 5-foot 3-inch bolts equal 1 unit.

Conversion of Cords to Board Feet

For many years two standard cords were considered to be equivalent to one MBF, Doyle scale (Chapman and Demeritt, 1936). However, because of the smaller-diameter logs now being utilized and because of the inaccuracy of applying log rules to small-diameter stock, cordwood volume should not be

TABLE 13.—Merchantable volume per tree in rough, standard stacked cords[1]

	Total tree height in feet							
Dbh	30	40	50	60	70	80	90	100
In.	Cords							
	Form class 65-69; Average 67							
6	0.029	0.035	0.040	0.045	0.052			
8	.055	.063	.074	.084	.094	0.104		
10		.097	.115	.132	.148	.165	0.179	
12		.136	.160	.182	.207	.226	.250	0.272
14			.221	.250	.280	.309	.343	.372
16			.277	.313	.350	.391	.433	.469
	Form class 75-79; Average 77							
6	0.036	0.045	0.052	0.058	0.068			
8	.069	.081	.096	.109	.122	0.136		
10		.124	.148	.170	.192	.213	0.232	
12		.174	.207	.236	.269	.295	.328	0.357
14			.282	.321	.360	.399	.443	.482
16			.357	.407	.455	.511	.566	.627
	Form class 85-89; Average 87							
6	0.044	0.055	0.064	0.072	0.084			
8	.087	.101	.120	.136	.153	0.169		
10		.154	.185	.213	.240	.268	0.292	
12		.216	.258	.295	.336	.368	.410	0.447
14			.351	.401	.451	.501	.557	.607
16			.444	.506	.568	.638	.708	.770

[1] Compiled from Minor's form class volume tables.

Source: Burns, Paul Y. 1965. A condensation of Minor's form class volume tables for southern pine pulpwood. La. Agr. Exp. Sta., LSU Forestry Note 61.

expressed in terms of board foot units unless it is cut from round bolts large enough for lumber manufacture. A safe figure is 3.0 to 3.5 cords per MBF, Doyle log scale.

When stacking small crooked material, 333 board feet, Doyle scale, per cord may be used for firewood.

A factor of 5½ board feet per cubic foot is recommended for general use to convert cords to board feet for statistical summaries on wood production. The factor of board feet per cord would then depend on the average cubic volume per cord (Chapman and Meyer, 1949).

The remainder of the tables for the cord volume factors are self-explanatory by the use of table footnotes.

TABLE 14.—Merchantable volume per acre of 9- to 16-year-old slash pine plantations

Trees	Total height of tallest trees in feet					
per acre	25	30	35	40	45	50
No.	Cords					
400	0.30	5.39	10.49	15.59	20.69	25.78
500	1.62	6.71	11.81	16.91	22.01	27.11
600	2.94	8.04	13.13	18.23	23.33	28.43
700	4.26	9.36	14.46	19.55	24.65	29.75
800	5.58	10.68	15.78	20.87	25.97	31.07
900	6.90	12.00	17.10	22.20	27.29	32.39
1000	8.22	13.32	18.42	23.52	28.62	33.71

Source: Goggans, James F., and E. Fred Schultz. 1958. Growth of pine plantations in Alabama's coastal plain. Ala. Agr. Exp. Sta. Bull. 313.

TABLE 15.—Topwood volume per tree in rough cords[1]

	Number of 16-foot logs removed					
Dbh	1	1½	2	2½	3	3½
In.	Topwood volume in cords					
	Slash Pine					
9	0.062	0.064	0.066			
10	.050	.052	.054	0.054		
11	.041	.043	.044	.045	0.045	
12	.034	.036	.037	.038	.038	0.038
13	.029	.031	.032	.032	.032	.033
14	.025	.027	.027	.028	.028	.028
15	.022	.023	.024	.024	.024	.024
16	.019	.020	.021	.021	.021	.021
17	.017	.018	.019	.019	.019	.019
18	.015	.016	.017	.017	.017	.017
	Longleaf Pine					
9	0.054	0.046				
10	.046	.039	0.035	0.033		
11	.039	.033	.029	.027	0.025	
12	.032	.027	.024	.023	.022	0.021
13	.026	.023	.021	.019	.018	.018
14	.023	.020	.018	.017	.016	.015
15	.020	.017	.015	.014	.014	.013
16	.017	.015	.014	.013	.012	.012
17	.015	.014	.012	.012	.011	.011
18	.014	.012	.011	.010	.010	.009

[1] Merchantable top to 4 inches outside bark after removal of the number of sawlogs specified.

Source: Bennett, Frank A. 1953. Topwood volume tables for slash and longleaf pine. U.S. Forest Serv., Southeast. Forest Exp. Sta., Res. Note 42.

Board Foot-Log Scale Factors

The principal application of log scaling is the measurement of forest products to be sold. Additional scaling may be conducted, however, to measure work accomplished, to check the accuracy of a cruise, or to determine volumes for research work. Scaling practices themselves are highly variable and generally depend upon the following conditions:

1. Rules and regulations governing scaling practices in an area.
2. Organizational policies and traditions.
3. Defect characteristics of the species.
4. Defect characteristics of logs taken from different sites within the area. Both mechanical and pathological defects vary with differences in site.
5. The proportion of the various lumber grades and qualities of veneer stock that a log will yield.
6. Market value of the raw material being measured.
7. Identification of different tree species in the area.

TABLE 16.—Gross volume of trees, Doyle log scale
Form Class 78

Dbh	Merchantable height in number of 16-foot logs										
	1	1½	2	2½	3	3½	4	4½	5	5½	6
In.	Volume in board feet										
10	14	17	20	21	22	-	-	-	-	-	-
11	22	27	32	35	38	-	-	-	-	-	-
12	29	36	43	48	53	54	56	-	-	-	-
13	38	48	59	66	73	76	80	-	-	-	-
14	48	62	75	84	93	98	103	-	-	-	-
15	60	78	96	108	121	128	136	-	-	-	-
16	72	94	116	132	149	160	170	-	-	-	-
17	86	113	140	161	182	196	209	-	-	-	-
18	100	132	164	190	215	232	248	-	-	-	-
19	118	156	195	225	256	276	297	-	-	-	-
20	135	180	225	261	297	322	346	364	383	-	-
21	154	207	260	302	344	374	404	428	452	-	-
22	174	234	295	344	392	427	462	492	521	-	-
23	195	264	332	388	444	483	522	558	594	-	-
24	216	293	370	433	496	539	582	625	668	-	-
25	241	328	414	486	558	609	660	709	758	-	-
26	266	362	459	539	619	678	737	793	849	-	-
27	292	398	505	594	684	749	814	877	940	-	-
28	317	434	551	651	750	820	890	961	1032	1096	1161
29	346	475	604	714	824	902	980	1061	1142	1218	1294
30	376	517	658	778	898	984	1069	1160	1251	1339	1427
31	408	562	717	850	983	1080	1176	1273	1370	1470	1570
32	441	608	776	922	1068	1176	1283	1386	1488	1600	1712
33	474	654	835	994	1152	1268	1385	1497	1609	1734	1858
34	506	700	894	1064	1235	1361	1487	1608	1730	1866	2003
35	544	754	964	1149	1334	1472	1610	1743	1876	2020	2163
36	581	808	1035	1234	1434	1583	1732	1878	2023	2173	2323
37	618	860	1102	1318	1534	1694	1854	2013	2172	2332	2492
38	655	912	1170	1402	1635	1805	1975	2148	2322	2491	2660
39	698	974	1250	1498	1746	1932	2118	2298	2479	2662	2844
40	740	1035	1330	1594	1858	2059	2260	2448	2636	2832	3027

Source: Mesavage, Clement, and James W. Girard. 1956. Tables for estimating board-foot volume of timber. U.S. Department of Agr., Forest Service.

A log scale can only approximate the manufactured volume because of constant changes in product-mix, scaling practices, and even the varying skill of individual scalers. Therefore, even though a log scale is based on sound mathematical reasoning, it provides an arbitrary measure of volume.

Tree Volumes

Gross tree volumes, as shown in Tables 16, 17, 18 for form class 78, have been compiled for estimating the board foot volume of second-growth timber for three log rules: Doyle, Scribner, and International ¼-inch kerf. For application as local net volume tables, sample trees should be scaled by height classes to obtain an average defect for the class. Table values are then reduced by this amount.

If the computed average form class for a stand of timber does not fit the above form class volume table, table values may be altered at the rate of a 3 percent change for each unit change in form class.

A tree tapers from the stump to the top and not necessarily in a uniform

TABLE 17.—Gross volume of trees, Scribner log scale
Form Class 78

	Merchantable height in number of 16-foot logs										
Dbh	1	1½	2	2½	3	3½	4	4½	5	5½	6
In.	Board feet										
10	28	36	44	48	52	-	-	-	-	-	-
11	38	49	60	67	74	-	-	-	-	-	-
12	47	61	75	85	95	100	106	-	-	-	-
13	58	76	94	107	120	128	136	-	-	-	-
14	69	92	114	130	146	156	166	-	-	-	-
15	82	109	136	157	178	192	206	-	-	-	-
16	95	127	159	185	211	229	247	-	-	-	-
17	109	146	184	215	246	268	289	-	-	-	-
18	123	166	209	244	280	306	331	-	-	-	-
19	140	190	240	281	322	352	382	-	-	-	-
20	157	214	270	317	364	398	432	459	486	-	-
21	176	240	304	358	411	450	490	523	556	-	-
22	194	266	338	398	458	504	549	588	626	-	-
23	214	294	374	441	508	558	607	652	698	-	-
24	234	322	409	484	558	611	665	718	770	-	-
25	258	355	452	534	617	678	740	799	858	-	-
26	281	388	494	585	676	745	814	880	945	-	-
27	304	420	536	636	736	811	886	959	1032	-	-
28	327	452	578	686	795	877	959	1040	1120	1190	1261
29	354	491	628	746	864	953	1042	1132	1222	1306	1389
30	382	530	678	806	933	1028	1124	1224	1325	1421	1517
31	411	571	731	871	1011	1117	1223	1328	1434	1541	1648
32	440	612	784	936	1089	1206	1322	1432	1543	1661	1779
33	469	654	838	1001	1164	1280	1414	1534	1654	1783	1912
34	498	695	892	1066	1239	1373	1507	1636	1766	1906	2046
35	530	742	954	1141	1328	1473	1618	1757	1896	2044	2192
36	563	789	1015	1216	1416	1572	1728	1877	2026	2182	2338
37	596	836	1075	1290	1506	1670	1835	1998	2160	2324	2488
38	629	882	1135	1366	1596	1769	1942	2118	2295	2466	2637
39	666	935	1204	1449	1694	1881	2068	2251	2434	2616	2799
40	703	988	1274	1532	1791	1993	2195	2384	2574	2768	2961

Source: Mesavage, Clement, and James W. Girard. 1956. Tables for estimating board-foot volume of timber. U.S. Department of Agr., Forest Service.

pattern. Butts and tops usually have the greatest deviation in form, while intermediate logs more closely approximate true cylindrical shape. Taper factors in Table 19 are based on average values for several species and may be applied with reasonable accuracy in the construction of board foot and cubic foot volume tables.

Table 20 provides a log-by-log estimate of quantity and quality losses due to defects. By following the procedure outlined in Table 21, defect allowances based on the Scribner log rule may be obtained. Use of the appropriate converting factor from Table 22 will yield defect volume in either the Doyle or International rule.

Log Volumes

Volumes of 16-foot logs to the nearest board foot, with scaling diameters in tenths of inches, have been compiled for the three major log rules for the purpose of volume table construction (Tables 23, 24, and 25). Similar volumes are given for 8-foot logs based on strict application of the International

TABLE 18.—Gross volume of trees, International ¼-inch log scale
Form Class 78

	Merchantable height in number of 16-foot logs										
Dbh	1	1½	2	2½	3	3½	4	4½	5	5½	6
In.	Board feet										
10	36	48	59	66	73	----	----	----	----	----	----
11	46	61	76	86	96	----	----	----	----	----	----
12	56	74	92	106	120	128	137	----	----	----	----
13	67	90	112	130	147	158	168	----	----	----	----
14	78	105	132	153	174	187	200	----	----	----	----
15	92	124	156	182	208	225	242	----	----	----	----
16	106	143	180	210	241	263	285	----	----	----	----
17	121	164	206	242	278	304	330	----	----	----	----
18	136	184	233	274	314	344	374	----	----	----	----
19	154	209	264	311	358	392	427	----	----	----	----
20	171	234	296	348	401	440	480	511	542	----	----
21	191	262	332	391	450	496	542	579	616	----	----
22	211	290	368	434	500	552	603	647	691	----	----
23	231	318	404	478	552	608	663	714	766	----	----
24	251	346	441	523	605	664	723	782	840	----	----
25	275	380	484	574	665	732	800	865	930	----	----
26	299	414	528	626	725	801	877	949	1021	----	----
27	323	448	572	680	788	870	952	1032	1111	----	----
28	347	482	616	733	850	938	1027	1114	1201	1280	1358
29	375	521	667	794	920	1016	1112	1210	1308	1398	1488
30	403	560	718	854	991	1094	1198	1306	1415	1517	1619
31	432	602	772	921	1070	1184	1299	1412	1526	1640	1754
32	462	644	826	988	1149	1274	1400	1518	1637	1762	1888
33	492	686	880	1053	1226	1360	1495	1622	1750	1888	2026
34	521	728	934	1119	1304	1447	1590	1727	1864	2014	2163
35	555	776	998	1196	1394	1548	1702	1851	2000	2156	2312
36	589	826	1063	1274	1485	1650	1814	1974	2135	2298	2461
37	622	873	1124	1351	1578	1752	1926	2099	2272	2444	2616
38	656	921	1186	1428	1670	1854	2038	2224	2410	2590	2771
39	694	976	1258	1514	1769	1968	2166	2359	2552	2744	2937
40	731	1030	1329	1598	1868	2081	2294	2494	2693	2898	3103

Source: Mesavage, Clement, and James W. Girard. 1956. Tables for estimating board-foot volume of timber. U.S. Department of Agr., Forest Service.

rule (Table 26). Volumes for 8-foot logs for Doyle and Scribner may be obtained by taking one-half of the appropriate value for 16-foot logs.

Doyle, International, and Scribner log rules are presented in Tables 27, 28, and 29. All three major log rules that are common to this region vary with the method of application and with local scaling practices, but the International rule furnishes the most reliable and consistent prediction of lumber yield. To use the tables, follow the prescribed directions: If the log is 12 feet in length and the scaling diameter is 16 inches, the board-foot table values are 108, Doyle; 130, International; and 120, Scribner. This is gross volume, and no allowances are made for defects. If timber is cut for sale, the buyer's rule for deducting defect should be known.

Row and Guttenberg (1966) expressed these same three log rules in the form of regression equations, as functions of scaling diameter and log length.

TABLE 19.—Average upper-log taper in inches for 16-foot logs

	Number of 16-foot logs per tree														
	2	3		4			5				6				
Dbh	Position of each log within the tree														
	2nd	2nd	3rd	2nd	3rd	4th	2nd	3rd	4th	5th	2nd	3rd	4th	5th	6th
In.	Inches														
10	1.4	1.2	1.4	---	---	---	---	---	---	---	---	---	---	---	---
12	1.6	1.3	1.5	1.1	1.4	1.9	---	---	---	---	---	---	---	---	---
14	1.7	1.4	1.6	1.2	1.5	2.0	---	---	---	---	---	---	---	---	---
16	1.9	1.5	1.7	1.2	1.6	2.1	---	---	---	---	---	---	---	---	---
18	2.0	1.6	1.8	1.3	1.7	2.2	---	---	---	---	---	---	---	---	---
20	2.1	1.7	1.9	1.4	1.8	2.4	1.1	1.6	2.2	2.9	---	---	---	---	---
22	2.2	1.8	2.0	1.4	2.0	2.5	1.1	1.7	2.3	2.9	---	---	---	---	---
24	2.3	1.8	2.2	1.5	2.2	2.6	1.1	1.8	2.4	3.1	---	---	---	---	---
26	2.4	1.9	2.3	1.5	2.3	2.7	1.1	1.9	2.5	3.2	---	---	---	---	---
28	2.5	1.9	2.5	1.6	2.4	2.8	1.2	1.9	2.6	3.3	0.9	1.4	2.1	3.2	4.4
30	2.6	2.0	2.6	1.7	2.5	3.0	1.2	2.0	2.7	3.5	.9	1.4	2.1	3.2	4.5
32	2.7	2.0	2.7	1.7	2.5	3.1	1.2	2.1	2.9	3.7	1.0	1.4	2.1	3.2	4.6
34	2.8	2.1	2.7	1.8	2.5	3.3	1.3	2.1	3.0	3.8	1.0	1.4	2.2	3.3	4.7
36	2.8	2.1	2.8	1.8	2.6	3.4	1.3	2.2	3.0	3.9	1.1	1.5	2.2	3.3	4.9
38	2.9	2.1	2.8	1.9	2.6	3.4	1.3	2.2	3.1	3.9	1.1	1.5	2.3	3.4	5.1
40	2.9	2.2	2.8	1.9	2.7	3.4	1.4	2.3	3.2	4.0	1.2	1.5	2.4	3.5	5.3

Source: Mesavage, Clement, and James W. Girard. 1956. Tables for estimating board-foot volume of timber. U.S. Department of Agr., Forest Service.

TABLE 20.—Distribution of total tree volume by log position[1]
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Log	Number of 16-foot logs								
position	1	1½	2	2½	3	3½	4	4½	5
	Percent								
Butt	100	74	59	52	47	41	39	34	33
2nd		26	41	36	33	30	29	27	26
3rd				12	20	21	20	20	19
4th						8	12	14	14
								5	8

[1] Values given in percent of total tree volume.

Source: Rothacher, J. S. 1948. Percentage distribution of tree volume by logs. Jour. Forestry 46:115-118.

TABLE 21.—Deductions for defect in board feet, Scribner Decimal C log rule, based on defect length and cross-sectional area of defect[1]

Defect length	Deduction in board feet																			
	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200
Ft.	Cross-sectional area of defect in square inches																			
2	38	113	188	263	338	413	488	563	638											
4	19	57	94	132	169	207	244	282	319	357	394	432	469	507	544	582	619	657		
6	13	38		88	113	138	163	188	213	238	263	288	313	338	363	388	413	438	463	488
8	10	29	47	66	85	104	122	141	160	179	197	216	235	254	272	291	310	329	347	366
10	8	23	38	53	68	83	98	113	128	143	158	173	188	203	218	233	248	263	278	293
12	7	19	32	44	57	69	82	94	107	119	132	144	157	169	182	194	207	219	232	244
14	6	17	27	38	49	59	70	81	92	102	113	124	134	145	156	167	177	188	199	209
16	5	15	24	33	43	52	61	71	80	90	99	108	118	127	136	146	155	165	174	183
18	5	13	21	30	38	46	55	63	71	80	88	96	105	113	121	130	138	146	155	163
20	4	12	19	27	34	42	49	57	64	72	79	87	94	102	109	117	124	132	139	147

[1] Example for use: Determine the length of the defect in feet and the area occupied by the end of the defect in square inches. End of defect measures 9 in. x 11 in. (99 sq. in.). Length of defect is 12 feet. From defect length of 12 feet read horizontally to 99 sq. in., or next lower number found (in this case 94). Read up to find deduction of 80 board feet at column head.

Source: U.S. Forest Service. 1965. Service foresters handbook. Division of State and Private Forestry, Atlanta.

TABLE 22.—Defect conversions for Doyle and International ¼-inch log rules[1]

Doyle log rule		International log rule	
Scaling diameter	Factor	Scaling diameter	Factor
Logs 8 to 11 In	0.6	Logs 8 to 14 in.	1.2
Logs 12 to 13 In.	0.8	Logs 15 to 19 In.	1.1
Logs 14 to 20 In.	0.9	Logs 20 to 36 In.	1.05
Logs 21 to 31 In.	1.0	**Logs 37 In. and up**	1.0
Logs 32 to 40 In.	1.1		

[1] When scaling by the Doyle or International rule, allowances for defect should be computed from Table 21, the Forest Service defect table, and then be multiplied by the above factors.

Source: Forestry Handbook, edited by Reginald D. Forbes. Copyright 1955. The Ronald Press Company, New York. –

This simplification should facilitate the application of log rules in linear programming studies conducted throughout the lumber industry. The following regressions were developed:

Doyle

$$V = 0.625D^2L - 0.500DL + 1.000L$$

Scribner

$$V = .0494D^2L - 0.124DL + .269L$$

International ¼-inch

$$V = .0498D^2L - .185DL + .0422L + .00622DL^2 + .000259L^3 - .0116L^2$$

where V equals volume in board feet, D is scaling diameter, and L is scaling length.

Table 30, giving values for different log rules in percent of the International scale, shows the variability and inconsistency in measuring logs by different rules. This table is provided for comparison purposes only.

TABLE 23.—Volume of 16-foot logs to nearest board foot by Doyle log rule[1]

Scaling diameter	Scaling diameter in tenths of inches									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
In.	Board feet									
5	1	1	1	2	2	2	3	3	3	4
6	4	4	5	5	6	6	7	7	8	8
7	9	10	10	11	12	12	13	14	14	15
8	16	17	18	18	19	20	21	22	23	24
9	25	26	27	28	29	30	31	32	34	35
10	36	37	38	40	41	42	44	45	46	48
11	49	50	52	53	55	56	58	59	61	62
12	64	66	67	69	71	72	74	76	77	79
13	81	83	85	86	88	90	92	94	96	98
14	100	102	104	106	108	110	112	114	117	119
15	121	123	125	128	130	132	135	137	139	142
16	144	146	149	151	154	156	159	161	164	166
17	169	172	174	177	180	182	185	188	190	193
18	196	199	202	204	207	210	213	216	219	222
19	225	228	231	234	237	240	243	246	250	253
20	256	259	262	266	269	272	276	279	282	286
21	289	292	296	299	303	306	310	313	317	320
22	324	328	331	335	339	342	346	350	353	357
23	361	365	369	372	376	380	384	388	392	396
24	400	404	408	412	416	420	424	428	433	437
25	441	445	449	454	458	462	467	471	475	480
26	484	488	493	497	502	506	511	515	520	524
27	529	534	538	543	548	552	557	562	566	571
28	576	581	586	590	595	600	605	610	615	620
29	625	630	635	640	645	650	655	660	666	671
30	676	681	686	692	697	702	708	713	718	724
31	729	734	740	745	751	756	762	767	773	778
32	784	790	795	801	807	812	818	824	829	835
33	841	847	853	858	864	870	876	882	888	894
34	900	906	912	918	924	930	936	942	949	955

[1] Computed from formula $V = \frac{(D\text{-}4)^2 \times L}{16}$, where D = scaling diameter.

Source: Mesavage, Clement, and James W. Girard. 1956. Tables for estimating board-foot volume of timber. U.S. Department of Agr., Forest Service.

Procedure for Converting Among Different Log Rules

Log volumes in terms of one rule can be converted to another by using previous values for board foot rules, values in Table 31, and the following procedures by Lane and Schnur (1948):

1. To convert International volume to Doyle or Scribner, multiply the International volume by the percentage for the desired rule, log diameter, and length. Example: Given 1,000 board feet, International volume, in 14-inch logs 12 feet long, what is the Doyle volume?

1,000 times 0.77 equals 770 board feet, Doyle volume

2. To convert Doyle or Scribner volume to International, divide the Doyle or Scribner volume by the percentages for the given rule, log diameter, and length. Example: Given 1,000 board feet, Doyle volume, in 16-inch logs 10 feet long, what is the International volume?

1,000 divided by 0.83 equals 1,205 board feet International

3. Doyle volume can be converted to Scribner, or vice versa, by first changing to International and then to the desired rule, using the above procedures.

4. Dollar values per unit volume in terms of one rule can be converted to

TABLE 24.—Volume of 16-foot logs to nearest board foot by Scribner log rule[1]

Scaling	Scaling diameter in tenths of inches									
diameter	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
In.	Board feet									
6	12	13	14	15	16	16	17	18	19	20
7	21	22	23	24	24	25	26	27	28	29
8	30	31	32	33	34	36	37	38	39	41
9	42	43	45	46	47	48	50	51	52	54
10	55	56	58	60	61	63	64	66	67	69
11	70	72	74	75	77	78	80	81	83	84
12	86	88	90	91	93	95	97	99	101	102
13	104	106	108	110	111	113	115	117	119	121
14	123	125	127	129	131	133	135	137	140	142
15	144	146	148	150	153	155	157	159	161	164
16	166	168	171	173	175	177	180	182	185	187
17	189	191	194	196	199	202	204	207	210	213
18	216	218	221	224	227	229	231	234	237	240
19	243	245	248	251	254	257	260	263	266	269
20	272	275	278	281	284	287	290	293	296	299
21	302	305	308	311	314	317	320	323	327	330
22	334	337	340	344	348	351	354	358	361	365
23	368	372	375	379	382	386	390	394	397	400
24	403	406	410	414	418	422	426	429	432	436
25	440	444	448	452	456	460	464	468	472	475
26	478	482	486	490	494	498	502	506	510	514
27	518	522	526	530	534	538	542	546	550	554
28	559	563	567	571	575	579	583	587	592	597
29	602	606	611	615	620	624	629	633	638	642
30	647	651	656	660	665	669	674	678	683	688
31	693	698	703	708	712	717	722	726	731	736
32	741	746	751	756	761	766	770	775	780	785
33	790	795	800	805	810	815	820	825	830	835
34	841	846	851	856	862	867	872	877	883	888
35	894	900	905	910	915	921	926	931	937	942

[1] Computed from formula $V = .79D^2 - 2D - 4$, where D = scaling diameter.

Source: Mesavage, Clement, and James W. Girard. 1956. Tables for estimating board-foot volume of timber. U.S. Department of Agr., Forest Service.

another rule by substituting dollar values for log volumes in the above procedures and by dividing where multiplying is indicated and vice versa. Example: Given a number of logs 16 inches in diameter and 12 feet long, worth $100.00 per MBF, International scale, what is an equal value by the Doyle rule per MBF?

$100.00 divided by 0.82 equals $121.95

Overrun is greatly influenced at any mill by the width and thickness of the product, the mill efficiency, and the ability of the sawyer. Data in Table 32 are figures for a "better than average" mill producing a specific product-mix and are a good indication of the approximate overrun that can be expected when sawing a similar dimension-board mixture of pine yard lumber.

Sawlog Conversions—by Scaling Diameter

Sawlog converting factors for cubic and board foot volumes have been compiled in Tables 33 and 34 and are especially useful when more than one basis of volume measure is encountered in the marketing process. Values in Table 33 are based on actual field measurements of 16-foot shortleaf and lob-

TABLE 25.—Volume of 16-foot logs to nearest board foot by International ¼-inch log rule[1]

Scaling	Scaling diameter in tenths of inches									
diameter	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
In.	Board feet									
6	19	20	21	22	23	23	24	25	26	27
7	28	29	30	31	32	33	34	35	36	38
8	39	40	41	42	43	45	46	47	48	50
9	51	52	54	55	56	58	59	60	62	63
10	65	66	68	69	71	72	74	75	77	78
11	80	82	83	85	87	88	90	92	93	95
12	97	99	100	102	104	106	108	110	112	114
13	115	117	119	121	123	125	127	129	131	133
14	136	138	140	142	144	146	148	151	153	155
15	157	160	162	164	166	169	171	173	176	178
16	181	183	185	188	190	193	195	198	200	203
17	205	208	211	213	216	219	221	224	227	229
18	232	235	237	240	243	246	249	251	254	257
19	260	263	266	269	272	275	278	281	284	287
20	290	293	296	299	302	305	308	311	315	318
21	321	324	327	331	334	337	341	344	347	351
22	354	357	361	364	367	371	374	378	381	385
23	388	392	395	399	403	406	410	413	417	421
24	424	428	432	435	439	443	447	451	454	458
25	462	466	470	474	478	481	485	489	493	497
26	501	505	509	513	517	521	526	530	534	538
27	542	546	550	555	559	563	567	572	576	580
28	584	589	593	598	602	606	611	615	620	624
29	628	633	637	642	647	651	656	660	665	669
30	674	679	683	688	693	697	702	707	712	716
31	721	726	731	736	741	745	750	755	760	765
32	770	775	780	785	790	795	800	805	810	815
33	820	826	831	836	841	846	851	857	862	867
34	872	878	883	888	894	899	904	910	915	921
35	926	931	937	942	948	953	959	964	970	976

[1] Computed from formula $V = 0.796D^2 - 1.375D - 1.230$, where D = scaling diameter.

Source: Mesavage, Clement, and James W. Girard. 1956. Tables for estimating board-foot volume of timber. U.S. Department of Agr., Forest Service.

TABLE 26.—Volume of 8-foot logs to nearest board foot by International ¼-inch log rule[1]

Scaling diameter	Scaling diameter in tenths of inches									
	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
In.	Board feet									
6	8	8	9	9	9	10	10	10	11	11
7	12	12	13	13	13	14	14	15	16	16
8	17	17	18	18	19	19	20	20	21	22
9	22	23	23	24	25	25	26	27	27	28
10	29	29	30	31	31	31	32	33	34	35
11	36	37	38	38	39	40	41	42	42	43
12	44	45	46	47	47	48	49	50	51	52
13	53	54	55	56	57	58	59	60	61	62
14	63	66	65	66	67	68	69	70	71	72
15	73	74	75	76	77	79	80	81	82	83
16	84	85	87	88	88	90	91	93	94	95
17	96	98	99	100	101	103	104	105	107	108
18	109	110	112	113	115	116	117	119	120	121
19	123	124	126	127	129	130	131	133	134	136
20	137	139	140	142	143	145	146	148	149	151
21	152	154	156	157	159	160	162	164	165	167
22	169	170	172	174	175	179	179	180	182	184
23	185	187	189	191	192	194	196	198	200	201
24	203	205	207	208	210	212	214	216	217	220
25	221	224	225	227	229	231	233	235	237	239
26	241	243	245	247	249	251	253	255	257	259
27	262	264	265	266	269	271	273	275	277	279
28	282	284	286	288	290	292	294	296	299	301
29	303	305	307	310	312	314	316	319	321	323
30	325	329	330	332	334	337	339	342	343	346

[1] Computed from formula $V = .905\ (.44D^2 - 1.20D - .3)$, where D is scaling diameter.

TABLE 27.—Doyle log rule, contents of logs in board feet

Scaling diameter	Log length in feet					
	6	8	10	12	14	16
In.	Board feet					
6	2	2	3	3	4	4
7	3	5	6	7	8	9
8	6	8	10	12	14	16
9	9	13	16	19	22	25
10	14	18	23	27	32	36
11	18	25	31	37	43	49
12	24	32	40	48	56	64
13	30	41	51	61	71	81
14	38	50	63	75	88	100
15	45	61	76	91	106	121
16	54	72	90	108	126	144
17	63	85	106	127	148	169
18	74	98	123	147	172	196
19	84	113	141	169	197	225
20	96	128	160	192	224	256
21	108	145	181	217	253	289
22	122	162	203	243	284	324
23	135	181	226	271	316	361
24	150	200	250	300	350	400
25	165	221	276	331	386	441
26	182	242	303	363	424	484
27	198	265	331	397	463	529
28	216	288	360	432	504	576
29	234	313	391	469	547	625
30	254	338	423	507	592	676

TABLE 28.—International ¼-inch log rule, contents of logs in board feet

Scaling diameter	Log length in feet					
	6	8	10	12	14	16
In.	Board feet					
6	5	10	10	15	15	20
7	10	10	15	20	25	30
8	10	15	20	25	35	40
9	15	20	30	35	45	50
10	20	30	35	45	55	65
11	25	35	45	55	70	80
12	30	45	55	70	85	95
13	40	55	70	85	100	115
14	45	65	80	100	115	135
15	55	75	95	115	135	160
16	60	85	110	130	155	180
17	70	95	125	150	180	205
18	80	110	140	170	200	230
19	90	125	155	190	225	260
20	100	135	175	210	250	290
21	115	155	195	235	280	320
22	125	170	215	260	305	355
23	140	185	235	285	335	390
24	150	205	255	310	370	425
25	165	220	280	340	400	460
26	180	240	305	370	435	500
27	195	260	330	400	470	540
28	210	280	355	430	510	585
29	225	305	385	465	545	630
30	245	325	410	495	585	675

TABLE 29.—Scribner Decimal C log rule, contents of logs in board feet

Scaling diameter	Log length in feet					
	6	8	10	12	14	16
In.	Board feet					
6	5	5	10	10	10	20
7	5	10	10	20	20	30
8	10	10	20	20	20	30
9	10	20	30	30	30	40
10	20	30	30	30	40	60
11	20	30	40	40	50	70
12	30	40	50	60	70	80
13	40	50	60	70	80	100
14	40	60	70	90	100	110
15	50	70	90	110	120	140
16	60	80	100	120	140	160
17	70	90	120	140	160	180
18	80	110	130	160	190	210
19	90	120	150	180	210	240
20	110	140	170	210	240	280
21	120	150	190	230	270	300
22	130	170	210	250	290	330
23	140	190	230	280	330	380
24	150	210	250	300	350	400
25	170	230	290	340	400	460
26	190	250	310	370	440	500
27	210	270	340	410	480	550
28	220	290	360	440	510	580
29	230	310	380	460	530	610
30	250	330	410	490	570	660

lolly pine logs in Arkansas, but the factors will be applicable to any species with similar taper. Factors for 8-foot logs were determined by the application of log rule formulae.

Scaling diameter, log volume, or log scale volume for 8-foot and 16-foot logs may be determined for any diameter class if any one of these values is known. To convert values per MBF International to any other board foot scale, divide the International volume by the appropriate converting factor. To change Doyle, Scribner, or cubic volumes to International volume, multiply by the converting factor for the appropriate scaling diameter. To convert among the Doyle, Scribner, or cubic volumes, first obtain the equivalent volume in the International rule and then convert to the desired measure.

TABLE 30.—Board foot volumes of 16-foot logs for International rule and other log rules in percent of the International rule

Scaling diameter	International[1]	Scribner	Scribner Decimal C	Doyle	Doyle-Scribner	**Modified Doyle rule**
In.	Bd. Ft.	Percent				
6	20	90	100	20	20	115
7	30	80	100	30	30	104
8	40	80	75	40	40	102
9	50	84	80	50	50	103
10	65	83	92	55	55	98
11	80	80	88	61	61	126
12	95	83	84	67	67	97
13	115	84	87	70	70	94
14	135	84	81	74	74	93
15	160	89	88	76	76	90
16	180	88	89	80	80	91
17	205	90	88	82	82	90
18	230	93	91	85	85	90
19	260	92	92	87	87	90
20	290	97	97	88	88	88
21	320	95	94	90	90	88
22	355	94	93	91	91	87
23	390	97	97	93	93	87
24	425	95	94	94	94	87
25	460	100	100	96	96	87
26	500	100	100	97	97	86
27	540	101	102	98	98	86
28	585	99	99	98	99	86
29	630	97	97	99	97	85
30	675	97	98	100	97	85
31	720	99	99	101	99	85
32	770	96	96	102	96	85
33	820	96	95	103	96	85
34	875	91	91	103	91	85
35	925	95	95	104	95	84
36	980	94	94	104	94	85
37	1040	99	99	105	99	84
38	1095	98	98	106	98	84
39	1155	97	97	106	97	84
40	1220	99	98	106	99	84

[1] ¼-inch Kerf.

TABLE 31.—Comparison of Doyle and Scribner volumes with the International rule—values given in percent of International log rule volume

Scaling diameter	Log length in feet									
	8		10		12		14		16	
	Doyle	Scribner	Doyle	Scribner	Doyle	Scribner	Doyle	Scribner	Doyle	Scribner
In.	Percent									
8	47	88	45	84	44	81	42	79	41	77
10	62	96	60	90	59	88	57	86	55	85
12	73	98	71	96	69	93	67	90	66	89
14	79	98	78	96	77	94	75	92	74	90
16	86	99	83	97	82	95	81	93	80	92
18	90	99	88	97	87	96	86	94	84	93
20	93	99	92	98	91	97	90	95	88	94
22	96	99	95	98	94	97	93	95	92	94
24	99	99	97	98	96	97	95	96	94	95
26	100	99	99	98	99	97	98	96	97	95
28	102	99	101	98	100	97	99	96	99	96
30	104	99	103	98	102	98	101	97	100	96
32	105	99	104	99	104	98	103	97	102	96
34	106	99	105	99	105	98	104	97	103	96
36	107	99	107	99	106	98	105	97	104	97
38	108	99	107	99	107	98	106	97	105	97
40	109	99	108	99	107	98	106	97	106	97

Source: Lane, Richard D., and G. Luther Schnur. 1948. Log rule comparison: International ¼-inch, Doyle, Scribner. U.S. Forest Serv., Central States Forest Exp. Sta., Sta. Note 47.

TABLE 32.—Percent overrun, by scaling diameter and log rule, from manufacture of southern pine lumber

Scaling diameter	Logs measured	Log rule		
		Doyle[1]	Scribner Decimal C[2]	International ¼-inch[3]
In.	No.	Percent		
6	70	+172	+21	−3
7	94	124	20	−4
8	106	95	19	−4
9	108	74	17	−4
10	115	59	16	−5
11	96	48	15	−5
12	82	39	14	−5
13	73	31	13	−6
14	59	25	11	−6
15	51	20	10	−6
16	27	16	9	−6
17	16	12	8	−7
18	11	8	6	−7
19	8	5	5	−7
20	4	2	4	−8
21	1	00	3	−8
Total	921			

[1] Prediction equation for Doyle overrun $= \dfrac{100}{-0.5411 + 1.1684 \log_{10} D} - 100$

[2] Prediction equation for Scribner overrun $= 28.6082 - 1.237D$

[3] Prediction equation for International overrun $= -1.5028 - 0.3086D$

Source: Rodenbach, Richard C. 1966. Southern yellow pine log over-runs. U.S. Forest Serv. Res. Note SE-56.

TABLE 33.—Board foot—cubic volume conversions for 16-foot logs

Scaling diameter	Board feet per log (International ¼ rule)[1]	Equivalent in:			To convert values per MBF, Int., to values based on Doyle, Scribner, or cubic, divide by the following figures:[2]			Number of cubic feet peeled volume per MBF when scaled by:		
		Doyle[1]	Scribner[1]	Cubic feet (i.b.)	Doyle	Scribner	Cubic feet	Int'l ¼	Doyle	Scribner
In.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Cu. Ft.	Ratios					
6.0	19	4	12	4.0	0.2105	0.6316	0.2105	210.5	1000.0	333.3
6.5	23	6	16	4.4	.2609	.6956	.1913	191.3	733.3	275.0
7.0	28	9	21	5.0	.3214	.7500	.1786	178.6	555.6	238.1
7.5	33	12	25	5.6	.3636	.7576	.1697	169.7	466.7	224.0
8.0	39	16	31	6.3	.4102	.7949	.1615	161.5	393.8	203.2
8.5	45	20	36	7.1	.4444	.8000	.1578	157.8	355.0	197.2
9.0	51	25	42	7.9	.4902	.8235	.1549	154.9	316.0	188.1
9.5	58	30	48	8.8	.5172	.8276	.1517	151.7	293.3	183.3
10.0	65	36	55	9.8	.5538	.8462	.1508	150.8	272.2	178.2
10.5	72	42	62	10.8	.5833	.8611	.1500	150.0	257.1	174.2
11.0	80	49	70	11.8	.6125	.8750	.1475	147.5	240.8	168.6
11.5	88	56	78	12.9	.6364	.8864	.1466	146.6	230.4	165.4
12.0	97	64	86	14.2	.6598	.8866	.1464	146.4	221.9	165.1
12.5	106	72	94	15.4	.6792	.8868	.1453	145.3	213.9	163.8
13.0	115	81	104	16.7	.7043	.9043	.1452	145.2	206.2	160.6
13.5	125	90	113	17.9	.7200	.9040	.1432	143.2	198.9	158.4
14.0	136	100	123	19.2	.7353	.9044	.1412	141.2	192.0	156.1
14.5	146	110	133	20.5	.7534	.9110	.1404	140.4	186.4	154.1
15.0	157	121	144	22.0	.7707	.9172	.1401	140.1	181.8	152.8
15.5	169	132	155	23.5	.7811	.9172	.1390	139.0	178.0	151.6
16.0	181	144	166	25.0	.7956	.9171	.1381	138.1	173.6	150.6

(Continued)

TABLE 33 —Continued) **Board foot—cubic volume conversions for 16-foot logs**

Scaling diameter	Board feet per log (International ¼ rule)[1]	Equivalent in:			To convert values per MBF, Int., to values based on Doyle, Scribner, or cubic, divide by the following figures:[2]			Number of cubic feet peeled volume per MBF when scaled by:		
		Doyle[1]	Scribner[1]	Cubic feet (i.b.)	Doyle	Scribner	Cubic feet	Int'l ¼	Doyle	Scribner
In.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Cu. Ft.	Ratios					
16.5	193	156	178	26.7	0.8083	0.9223	0.1383	138.3	171.2	150.0
17.0	205	169	190	28.4	.8244	.9268	.1385	138.5	168.0	149.5
17.5	219	182	203	30.2	.8310	.9269	.1379	137.9	165.9	148.8
18.0	232	196	216	32.0	.8448	.9310	.1379	137.9	163.3	148.1
18.5	246	210	229	33.9	.8536	.9309	.1378	137.8	161.4	148.0
19.0	260	225	243	35.8	.8654	.9346	.1377	137.7	159.1	147.3
19.5	275	240	257	37.8	.8727	.9345	.1374	137.4	157.5	147.1
20.0	290	256	272	39.8	.8828	.9379	.1372	137.2	155.5	146.3
20.5	305	272	287	41.8	.8918	.9410	.1370	137.0	153.7	145.6
21.0	321	289	302	43.8	.9003	.9408	.1364	136.4	151.6	145.0
21.5	337	306	318	45.8	.9080	.9436	.1359	135.9	149.7	144.0
22.0	354	324	334	47.8	.9152	.9435	.1350	135.0	147.5	143.1

[1] Doyle scale computed from the formula: $V = (D\text{-}4)^2$
Scribner scale computed from formula: $V = 0.79D^2 - 2D - 4$
International ¼-inch scale computed from formula: $V = 0.796D^2 - 1.375D - 1.230$

[2] To convert board feet, International, to board feet based on either Doyle or Scribner scale, or to cubic feet, *multiply* by the given ratios.

Source: Reynolds, R. R. 1937. Factors for converting log and tree volumes and values from one common scale to another. U.S. Forest Serv., South. Forest Exp. Sta., Occ. Paper 68.

Sawtimber Converting Factors

To convert board foot or cubic volumes, given for different Dbh classes, from one scale to another, multiply the board foot or cubic foot volume by the converting factor from the appropriate column heading in Table 35. Board foot-cubic volume factors for shortleaf and loblolly pine trees in Southeast Arkansas, Table 36, were determined under field conditions similar to those conducted for sawlog conversion factors. Table values can be applied to shortleaf and loblolly pine growing locally or in other regions or to other species of southern pine having similar taper, log length, or upper limits of utilization.

Price Conversions for Timber Sales

Given the average board foot volume per tree and the Dbh class with the greatest volume for a stand of timber that has been marked, prices quoted in terms of Doyle or International can be converted to the Scribner basis by using Tables 37 and 38. For converting from the Scribner to Doyle or International rules, the inverse of table values should be used. Procedures for use are outlined as follows:

1. Determine the average board foot volume per tree and the Dbh class with the greatest volume for the entire sale area.
2. Using Table 37 for Doyle to Scribner conversions and Table 38 for International to Scribner conversions, find the multiplying factor for the appropriate Dbh class and volume.
3. Multiply the log volume by the corrected stumpage value to obtain a comparison of stumpage values based on different log rules.
4. To convert Scribner volumes to either Doyle or International, follow the same procedure for obtaining the correct multiplier. Instead of multiplying, however, divide the Scribner volume by the correct conversion factor to obtain the correct value based on either Doyle or International.

Scaling Deviations

Actual scaling practices differ widely from textbook scales. Some deviations occurring in the application of log rules are: giving logs 8 inches or less in diameter their length in feet as the board foot value; rounding scaling diameters to the nearest inch; and including various bark thicknesses in the diameter measurement. A modification of the Doyle rule, to include one bark thickness in the diameter, gives upward bias of:

Scaling diameter	Error
In.	Pct.
6	20.0
9	10.7
12	9.2
15	8.4
18	1.8

TABLE 34.—Board foot-cubic volume conversions for 8-foot sawlogs[1]

Scaling diameter	Board ft. per log, Int. ¼[2]	Equivalent in:		To convert values per MBF, Int., to values based on Doyle or cubic, divide by the following figures:		No. cubic feet peeled volume per MBF when scaled by:	
		Doyle[3]	Cubic[4]	Doyle[5]	Cubic[5]	Int. ¼	Doyle
In.	Bd. Ft.	Bd. Ft.	Cu. Ft.	Ratios			
6.0	7.5	2.0	1.85	.226	.247	246.7	925.0
6.5	9.5	3.1	2.14	.326	.225	225.3	690.3
7.0	11.6	4.5	2.49	.338	.215	214.6	553.3
7.5	13.9	6.1	2.79	.439	.201	200.7	457.3
8.0	16.5	8.0	3.16	.485	.192	191.5	395.0
8.5	19.2	10.0	3.54	.526	.184	184.4	350.5
9.0	22.2	12.5	3.94	.563	.177	177.9	315.2
9.5	25.3	15.1	4.36	.597	.172	172.3	288.7
10.0	28.7	18.0	4.81	.627	.168	167.6	267.2
10.5	32.2	21.1	5.28	.655	.164	163.9	250.2
11.0	36.0	24.5	5.77	.680	.160	160.3	235.5
11.5	39.9	28.1	6.28	.704	.157	157.4	223.4
12.0	44.0	32.0	6.82	.727	.155	155.0	213.1
12.5	48.4	36.1	7.38	.746	.152	152.5	204.4
13.0	52.9	40.5	7.96	.776	.150	150.5	196.5
13.5	57.6	45.1	8.55	.782	.148	148.4	189.6
14.0	62.6	50.0	9.18	.799	.147	146.6	183.6
14.5	67.7	55.1	9.82	.814	.145	145.0	178.2
15.0	73.0	60.5	10.49	.829	.144	143.7	173.3
15.5	78.6	66.1	11.17	.841	.142	142.1	168.9
16.0	84.3	72.0	11.88	.854	.141	140.9	165.0
16.5	90.2	78.1	12.61	.866	.140	139.8	161.4
17.0	96.3	84.5	13.37	.877	.139	138.8	158.2
17.5	102.7	91.1	14.14	.887	.138	137.7	155.2
18.0	109.2	98.0	14.94	.897	.137	136.8	152.4
18.5	115.9	105.1	15.75	.907	.136	135.9	149.8
19.0	122.8	112.5	16.60	.916	.135	135.1	147.6
19.5	129.9	120.1	17.45	.925	.134	134.3	145.3
20.0	137.3	128.0	18.34	.932	.134	133.6	143.3
20.5	144.8	136.1	19.24	.940	.133	132.9	141.4
21.0	152.5	144.5	20.17	.948	.132	132.3	139.6
21.5	160.4	153.1	21.12	.954	.132	131.7	137.4
22.0	168.6	162.0	22.09	.961	.131	131.0	136.4
22.5	176.9	171.1	23.08	.967	.130	130.5	134.9
23.0	185.4	180.5	24.10	.974	.130	129.9	133.5
23.5	194.1	190.1	25.13	.979	.129	129.5	132.2
24.0	203.0	200.0	26.19	.986	.129	129.0	130.9
24.5	212.1	210.5	27.27	.992	.128	128.6	129.5
25.0	221.4	220.5	28.38	.996	.128	128.2	128.7
25.5	230.8	231.1	29.50	1.001	.128	128.3	127.6
26.0	240.7	242.0	30.64	1.005	.127	127.3	126.6
26.5	250.6	253.1	31.81	1.010	.127	126.9	125.7
27.0	260.7	264.5	33.00	1.015	.126	126.6	124.8
27.5	271.0	276.1	34.21	1.019	.126	126.2	123.9
28.0	281.5	288.0	35.44	1.023	.126	125.9	123.0
28.5	292.2	300.1	36.70	1.027	.126	125.6	122.3
29.0	303.1	312.5	37.97	1.031	.125	125.3	121.5
29.5	314.2	325.1	39.27	1.035	.125	125.0	120.8
30.0	325.5	338.0	40.59	1.038	.125	124.7	120.1

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[1] Table values derived empirically from volume formulae.

[2] International scale is computed from the formula: $V = .3982D^2 - 1.086D - .2715$

[3] Doyle scale is computed from the formula: $V = \frac{(D-4)^2 \times L}{16}$

[4] Cubic volume formula adapted from Row and Guttenberg (1966):
$V = 8k\,(D^2 + D + .333)$, where $k = .005454$

[5] To convert board feet in the International scale to board feet Doyle scale or to cubic feet, *multiply* by the given ratios.

TABLE 35.—Conversions among log rules and cubic volumes for southern pine sawtimber[1]

Dbh	Cubic feet to bd. ft.			Doyle to	Int'l to	Scribner	Int'l to	Doyle to	Scribner
	Doyle	Scribner	Int'l	Int'l	Doyle	to Int'l	Scribner	Scribner	to Doyle
In.	Ratios								
10	2.30	4.45	5.90	2.56	0.39	1.325	0.755	1.93	0.52
11	2.70	4.85	6.05	2.24	0.45	1.250	0.800	1.80	0.56
12	3.00	5.10	6.20	2.07	0.48	1.210	0.825	1.70	0.59
13	3.40	5.35	6.35	1.87	0.54	1.185	0.845	1.57	0.64
14	3.70	5.55	6.50	1.76	0.57	1.170	0.855	1.50	0.67
15	4.00	5.70	6.60	1.65	0.61	1.155	0.865	1.43	0.70
16	4.20	5.85	6.70	1.60	0.63	1.140	0.875	1.39	0.72
17	4.40	6.00	6.80	1.54	0.65	1.130	0.885	1.36	0.73
18	4.70	6.15	6.85	1.46	0.69	1.115	0.895	1.31	0.76
19	4.90	6.25	6.90	1.41	0.71	1.105	0.905	1.28	0.78
20	5.10	6.35	6.95	1.36	0.73	1.095	0.915	1.25	0.80
21	5.30	6.45	7.00	1.32	0.76	1.085	0.920	1.22	0.82
22	5.50	6.50	7.00	1.27	0.79	1.080	0.925	1.18	0.85
23	5.70	6.60	7.05	1.24	0.81	1.075	0.935	1.16	0.86
24	5.90	6.65	7.10	1.20	0.83	1.070	0.940	1.13	0.89
25	6.10	6.70	7.15	1.17	0.85	1.065	0.940	1.10	0.91

[1] Log rules represented in this table are Doyle, Scribner Decimal C, and International ¼-inch scale. Diameter measurements are expressed in inches at breast height (4½ feet above ground) outside bark.

Source: U. S. Forest Service. 1941. National forest scaling handbook. Washington, D.C.

TABLE 36.—Board foot-cubic volume conversions for merchantable lengths of loblolly and shortleaf pine trees in Southeast Arkansas

Dbh	Board feet per log (International ¼ rule)	Equivalent in:			To convert values per MBF, Int'l, to values based on Doyle, Scribner, or cubic, divide by the following figures:[1]			Number of cubic feet peeled volume per MBF when scaled by:		
		Doyle	Scribner	Cubic (i.b.)	Doyle	Scribner	Cubic	Int'l ¼	Doyle	Scribner
In.	Bd. Ft.	Bd. Ft.	Bd. Ft.	Cu. Ft.	Ratios					
10	53	20	32	13.1	0.3774	0.6038	0.2472	247.2	655.0	409.4
11	79	38	56	14.7	.4810	.7089	.1861	186.1	386.8	262.5
12	107	58	82	17.0	.5421	.7664	.1589	158.9	293.1	207.3
13	137	81	113	20.1	.5912	.8248	.1467	146.7	248.1	177.9
14	168	108	146	24.1	.6429	.8690	.1435	143.5	223.1	165.1
15	202	141	182	29.3	.6980	.9010	.1450	145.0	207.8	161.0
16	239	176	219	34.9	.7364	.9163	.1460	146.0	198.3	159.4
17	280	213	257	41.0	.7607	.9179	.1464	146.4	192.5	159.5
18	325	253	298	47.7	.7785	.9169	.1468	146.8	188.5	160.1
19	375	297	342	55.1	.7920	.9120	.1469	146.9	185.5	161.1
20	431	344	392	62.7	.7981	.9095	.1455	145.5	182.3	159.9
21	492	400	449	70.8	.8130	.9126	.1439	143.9	177.0	157.7
22	561	465	513	79.3	.8289	.9144	.1414	141.4	170.5	154.6
23	631	541	585	88.1	.8574	.9271	.1396	139.6	162.8	150.6
24	706	621	662	97.0	.8796	.9377	.1374	137.4	156.2	146.5
25	785	705	743	105.9	.8981	.9465	.1349	134.9	150.2	142.5
26	867	790	827	114.9	.9112	.9539	.1325	132.5	145.4	138.9
27	950	876	913	124.0	.9221	.9611	.1305	130.5	141.6	135.8
28	1033	963	1000	133.0	.9322	.9681	.1288	128.8	138.1	133.0
29	1116	1050	1090	142.0	.9409	.9767	.1272	127.2	135.2	130.3
30	1200	1140	1182	151.0	.9500	.9850	.1259	125.8	132.5	127.7

[1] To convert board feet in the International scale to board feet Doyle scale or Scribner scale, or to cubic feet, *multiply* by the given ratios.

Source: Reynolds, R. R. 1937. Factors for converting log and tree volumes or values from one common scale to another. U. S. Forest Serv., South. Forest Exp. Sta., Occ. Paper 68.

TABLE 37.—Factors for converting prices in terms of Doyle rule to a Scribner rule basis

Average volume per tree	Dbh class with greatest volume in inches								
	10	12	14	16	18	20	22	24	26
Bd. Ft.	Multipliers								
50	0.575	0.591	0.607	0.622	0.638	0.654	0.669	0.685	0.701
55	.583	.599	.614	.630	.646	.662	.677	.693	.709
60	.591	.607	.623	.639	.654	.670	.686	.701	.717
65	.600	.616	.631	.647	.663	.678	.694	.710	.725
70	.608	.624	.640	.655	.671	.687	.702	.718	.734
75	.616	.631	.647	.663	.679	.694	.710	.726	.741
80	.623	.639	.655	.670	.686	.702	.717	.733	.749
85	.630	.646	.662	.677	.693	.709	.724	.740	.756
90	.637	.652	.668	.684	.699	.715	.731	.746	.762
95	.642	.658	.674	.690	.705	.721	.737	.752	.768
100	.648	.664	.680	.695	.711	.727	.742	.758	.774
110	.658	.674	.690	.705	.721	.737	.752	.768	.784
120	.667	.683	.699	.714	.730	.746	.761	.777	.793
130	.675	.691	.707	.722	.738	.754	.769	.785	.801
140	.682	.698	.714	.729	.745	.761	.776	.792	.808
150	.688	.704	.720	.735	.751	.767	.783	.798	.814
160	.694	.710	.725	.741	.757	.773	.788	.804	.820
170	.699	.715	.730	.746	.762	.777	.793	.809	.824
180	.703	.719	.735	.750	.766	.782	.798	.813	.829
190	.708	.723	.739	.755	.770	.786	.802	.817	.833
200	.712	.727	.743	.759	.774	.790	.806	.821	.837
220	.718	.734	.749	.765	.781	.796	.812	.828	.844
240	.724	.739	.755	.771	.787	.802	.818	.834	.849
260	.728	.744	.760	.776	.791	.807	.823	.838	.854
280	.733	.748	.764	.780	.795	.811	.827	.843	.858
300	.737	.752	.768	.784	.799	.815	.831	.846	.862
350	.744	.760	.776	.791	.807	.823	.838	.854	.870
400	.750	.766	.781	.797	.813	.828	.844	.860	.875
450	.754	.770	.786	.801	.817	.833	.848	.864	.880
500	.758	.774	.790	.805	.821	.837	.852	.868	.884

Source: Anderson, W. C. 1961. A method of appraising pine sawtimber in South Carolina. U.S. Forest Serv., Southeast. Forest Exp. Sta., Sta. Paper 122.

TABLE 38.—Factors for converting prices in terms of International ¼-inch rule (or lumber tally) to a Scribner rule basis

Average volume	Dbh class with greatest volume in inches								
per tree	0	12	14	16	18	20	22	24	26
Bd. Ft.	Multipliers								
50	1.224	1.218	1.212	1.207	1.201	1.195	1.190	1.184	1.179
55	1.216	1.210	1.205	1.199	1.193	1.188	1.182	1.176	1.171
60	1.209	1.203	1.198	1.192	1.186	1.181	1.175	1.169	1.164
65	1.203	1.197	1.191	1.186	1.180	1.174	1.169	1.163	1.157
70	1.197	1.191	1.186	1.180	1.174	1.169	1.163	1.157	1.152
75	1.192	1.186	1.181	1.175	1.169	1.164	1.158	1.152	1.147
80	1.187	1.181	1.176	1.170	1.165	1.159	1.153	1.148	1.142
85	1.183	1.177	1.172	1.166	1.160	1.155	1.149	1.143	1.138
90	1.179	1.173	1.168	1.162	1.157	1.151	1.145	1.140	1.134
95	1.176	1.170	1.164	1.159	1.153	1.147	1.142	1.136	1.130
100	1.172	1.167	1.161	1.155	1.150	1.144	1.138	1.133	1.127
110	1.167	1.161	1.155	1.150	1.144	1.138	1.133	1.127	1.122
120	1.162	1.156	1.150	1.145	1.139	1.134	1.128	1.122	1.117
130	1.158	1.152	1.146	1.141	1.135	1.129	1.124	1.118	1.112
140	1.154	1.148	1.143	1.137	1.131	1.126	1.120	1.114	1.109
150	1.151	1.145	1.139	1.134	1.128	1.122	1.117	1.111	1.105
160	1.148	1.142	1.136	1.131	1.125	1.120	1.114	1.108	1.103
170	1.145	1.140	1.134	1.128	1.123	1.117	1.111	1.106	1.100
180	1.143	1.137	1.132	1.126	1.120	1.115	1.109	1.103	1.098
190	1.141	1.135	1.130	1.124	1.118	1.113	1.107	1.101	1.096
200	1.139	1.133	1.128	1.122	1.116	1.111	1.105	1.099	1.094
220	1.136	1.130	1.124	1.119	1.113	1.107	1.102	1.096	1.090
240	1.133	1.127	1.122	1.116	1.110	1.105	1.099	1.093	1.088
260	1.130	1.125	1.119	1.114	1.108	1.102	1.097	1.091	1.085
280	1.128	1.123	1.117	1.111	1.106	1.100	1.095	1.089	1.083
300	1.127	1.121	1.115	1.110	1.104	1.098	1.093	1.087	1.081
350	1.123	1.117	1.112	1.106	1.100	1.095	1089	1.083	1.078
400	1.120	1.115	1.109	1.103	1.098	1.092	1.086	1.081	1.075
450	1.118	1.112	1.107	1.101	1.096	1.090	1.084	1.079	1.073
500	1.116	1.111	1.105	1.099	1.094	1.088	1.082	1.077	1.071

Source: Anderson, W. C. 1961. A method of appraising pine sawtimber in South Carolina. U.S. Forest Serv., Southeast. Forest Exp. Sta., Sta. Paper 122.

TABLE 39.—Board foot volume, International, for use with aerial photographs[1]

Crown	Total visible height in feet						
diameter	50	60	70	80	90	100	110
Feet	Board feet						
10	64	77	90	103	115		
12	80	103	120	128	146	161	
14	101	122	140	161	182	203	223
16		144	166	190	215	239	263
18		170	198	227	256	285	313
20		198	231	264	297	330	363
22		231	270	308	348	386	424
24			311	355	400	445	490
26			344	394	443	493	542
28			386	441	497	552	607
30			429	491	552	613	675

[1] For rough estimates of southern pine (other than longleaf) in all-aged or low-density even-aged sawlog stands, assuming that form class averages 80.

Source: Minor, Charles O. 1953b. Preliminary volume tables for use with aerial photographs. Forest Farmer 12(10). 8-10, 11.

Cubic Volume Factors

Most cubic foot rules are based on mathematical formulae and on the assumption that the log is a cylinder. Therefore the volume is equal to the average basal area in cubic feet multiplied by the log length in feet. The principal variation among cubic foot rules is in the method of arriving at the average basal area. Basal area is the average cross-sectional area of a log.

As a general rule, cubic volume determinations are more accurate than either cord or board foot volume measurements. Cubic formulae provide estimates of actual wood volume, whereas the basis for other volume formulae is solid volume of cordwood or expected lumber recovery.

Board foot-cubic foot ratios vary greatly, depending upon usage. Theoretically, one cubic foot contains 12 board feet. For average values 6 should be used, though 10 is a conventional figure for approximations. When the conversion applies to trees, ratios of 3 to 8 should be applied (U.S. Department of Agriculture, 1935).

The number of cubic feet of wood per thousand board feet varies from 160 to 220. A working average is 183 cubic feet per MBF, International scale.

Cubic measure, offering consistency and uniformity, has been successfully incorporated into weight scaling techniques to yield a combination estimate that may eventually replace other scaling methods.

Log Volumes

Row and Guttenberg (1966) determined cubic volume based on geometric forms occurring in a single log. Their estimates more closely approximate actual volume than do simpler methods of calculating cubic volume. Variation in log shape, trim, and bark will generally alter the coefficients but not the algebraic form of the regression equation. Table 40, based on this regression, has been calculated for use in volume table construction or weight scaling methods. Table values are consistently greater than cubic volumes using either Huber's or Smalian's formula.

Form Class Volume Tables

A gross volume table for form class 78, Table 41, comparable to the three board foot form class Tables 16, 17, and 18, has been included for use in constructing local net volume tables. The same procedure described for using board foot tables should be followed. A table of basal area values is also included (Table 42).

When cruising pulpwood and tallying diameters of all trees, Table 43, a condensation of Minor's form class volume tables (1950), provides accurate estimates of the total cubic volume of wood, inside bark. A sufficient sample of total heights must be taken to establish a curve of height over diameter. Local net volume tables are then constructed by interpolating, from the correct form class group volume table, a volume for each diameter class based on Dbh and total height. Merrifield and Foil (1967) incorporated Minor's form class tables into a study of volume equations. Their work revealed that the tables were highly accurate and could be readily adapted to research work.

TABLE 40.—Cubic foot volume of sawlogs[1]

Scaling diameter	Log length in feet														
	4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
In.	Cubic feet														
6	0.85	1.85	2.99	4.30	5.79	7.56	9.33	11.40	13.70	16.22	18.98	21.99	25.26	28.81	32.64
7	1.15	2.49	3.94	5.61	7.48	9.56	11.85	14.37	17.13	20.14	23.42	26.96	30.80	34.92	39.35
8	1.48	3.16	5.02	7.10	9.39	11.91	14.67	17.68	20.96	24.51	28.34	32.46	36.89	41.64	46.71
9	1.87	3.94	6.23	8.76	11.52	14.53	17.81	21.36	24.30	29.31	33.74	38.48	43.56	48.97	54.73
10	2.29	4.81	7.58	10.59	13.86	17.41	21.24	25.37	29.80	34.54	39.62	45.03	50.79	56.91	63.40
11	2.76	5.77	9.05	12.60	16.43	20.55	24.98	29.73	34.80	40.21	45.98	52.10	58.59	65.46	72.73
12	3.28	6.82	10.65	14.78	19.21	23.95	29.03	34.44	40.20	46.35	52.80	59.69	66.96	74.62	82.71
13	3.83	7.96	12.39	17.13	22.20	27.62	33.38	39.50	45.99	52.87	60.14	67.80	75.89	84.40	93.35
14	4.43	9.18	14.25	19.66	25.42	31.54	38.03	44.91	52.18	59.85	67.93	76.45	85.39	94.78	104.64
15	5.07	10.49	16.25	22.37	29.86	35.73	43.00	50.66	58.76	67.27	76.21	85.61	95.46	105.78	116.58
16	5.76	11.88	18.38	25.25	32.52	40.42	48.27	56.78	65.73	75.12	84.97	95.29	106.10	117.38	129.18
17	6.49	13.37	20.63	28.30	36.39	44.90	53.84	63.24	73.09	83.41	94.21	105.50	117.30	129.60	142.43
18	7.27	14.94	23.02	31.53	40.48	49.87	59.72	70.04	80.84	92.13	103.93	116.24	127.07	142.43	156.34
19	8.08	16.60	25.54	34.93	44.78	55.11	65.92	77.20	88.99	101.30	114.13	127.49	141.41	155.87	170.90
20	8.95	18.34	28.19	38.51	49.31	60.60	72.39	84.70	97.54	110.90	124.81	139.87	154.31	169.92	186.12
21	9.85	20.17	30.97	42.26	54.06	66.37	79.20	92.56	106.47	120.94	135.97	151.58	167.78	184.58	201.99
22	10.80	22.09	33.88	46.19	59.02	72.38	86.29	100.75	115.79	131.41	147.60	164.41	181.82	199.85	218.52
23	11.79	24.10	36.93	50.29	64.20	78.67	93.70	109.31	125.51	142.32	159.72	177.76	196.42	215.73	235.70
24	12.83	26.19	40.10	54.57	69.60	83.21	101.41	118.21	135.62	153.66	172.32	191.63	211.60	232.22	253.53
25	13.91	28.38	43.41	59.02	75.22	92.02	109.43	127.46	146.13	165.44	185.40	206.03	227.34	249.33	272.02
26	15.03	30.64	46.84	63.64	81.05	99.09	117.75	137.06	156.99	177.66	198.96	220.95	243.65	267.02	291.18
27	16.20	33.00	50.41	68.44	87.11	106.42	126.38	147.01	168.32	190.31	213.00	236.40	260.52	285.37	310.96
28	17.41	35.44	54.11	73.42	93.38	114.01	135.32	157.31	180.00	203.40	227.52	252.37	277.96	304.31	331.42
29	18.66	37.97	57.94	78.57	99.87	121.86	144.50	167.95	192.07	216.93	242.52	268.86	295.97	323.85	352.52
30	19.96	40.59	61.90	83.89	106.58	129.98	154.10	178.95	204.54	230.89	257.99	285.88	314.55	344.01	374.28

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[1] Based on the formula: $V = kD^2L + \frac{kDL^2}{8} + \frac{kL^3}{192}$ where, D = scaling diameter; L = length in feet; and $k = \text{pi}/12^2 \times 4$ or 0.005454, the constant for converting D^2 in inches to area in square feet. The formula assumes that logs are segments of a cone tapering 1 inch in diameter for every 8 feet of log length and that there is no bark or allowance for trim. The formula was developed by Row and Guttenberg (1966).

Where defect is a problem the following formula may be used to determine the volumetric content in cubic feet of the defective area:

$$V = \frac{W \times H \times L}{144}$$

where V = volume in cubic feet, W = width of defective area in inches, H = height of defective area in inches, and L = length of defective area in feet. Unless logs are to be cut into lumber, however, no deductions are made for sweep or knots.

TABLE 41.—Gross cubic foot volume, inside bark
Form Class 78

Dbh	Length of merchantable stem in feet												
	12	16	20	24	28	32	36	40	44	48	52	56	60
In.	Cubic feet												
5	1.3	1.7	2.0	2.3	2.6	2.9	3.2	3.5	3.8	4.1	4.4	4.7	5.0
6	1.8	2.4	2.8	3.2	3.6	3.9	4.3	4.7	5.1	5.5	5.9	6.2	6.6
7	2.4	3.1	3.6	4.1	4.6	5.1	5.6	6.1	6.6	7.1	7.6	8.1	8.6
8	3.0	3.9	4.5	5.1	5.7	6.3	7.0	7.6	8.2	8.8	9.4	10.0	10.6
9	3.8	4.9	5.6	6.4	7.1	7.8	8.6	9.3	10.0	10.8	11.5	12.2	13.0
10	4.6	6.0	6.8	7.7	8.5	9.4	10.2	11.0	11.9	12.7	13.6	14.4	15.2

Dbh	Number of 16-foot logs										
	1	1½	2	2½	3	3½	4	4½	5	5½	6
In.	Cubic feet										
10	6.0	8.2	10.4	12.0	13.6						
11	7.4	10.1	12.8	14.8	16.9						
12	8.7	12.0	15.2	17.7	20.2	22.0	23.8				
13	10.2	14.0	17.9	20.8	23.8	26.0	28.2				
14	11.7	16.2	20.6	24.0	27.5	30.0	32.6				
15	13.6	18.7	23.8	27.9	32.0	35.2	38.4				
16	15.4	21.2	27.1	31.8	36.6	40.4	44.1				
17	17.4	24.0	30.6	36.0	41.4	45.7	50.0				
18	19.4	26.8	34.2	40.2	46.3	51.2	56.0				
19	21.7	30.0	38.4	45.2	52.0	57.5	63.0				
20	24.0	33.3	42.6	50.2	57.8	63.9	70.0	75.0	80.1		
21	26.8	37.1	47.4	55.9	64.4	71.3	78.2	84.0	89.9		
22	29.6	41.0	52.3	61.6	71.0	78.8	86.5	93.1	99.7		
23	32.4	44.8	57.3	67.6	78.0	86.3	94.6	102.2	109.7		
24	35.3	48.8	62.3	73.6	84.9	93.8	102.7	111.2	119.7		
25	38.6	53.4	68.1	80.4	92.8	102.8	112.8	122.1	131.4		
26	41.9	57.9	73.9	87.3	100.7	111.8	122.8	133.0	143.2		
27	45.2	62.5	79.8	94.4	108.9	120.8	132.6	143.8	155.0		
28	48.6	67.1	85.6	101.4	117.1	129.8	142.4	154.6	166.7	177.8	188.8
29	52.7	72.6	92.6	109.6	126.6	140.2	153.9	167.2	180.6	193.2	205.7
30	56.8	78.2	99.6	117.8	136.1	150.8	165.4	180.0	194.6	208.6	222.6
31	61.2	84.1	107.0	126.8	146.5	162.5	178.5	194.0	209.4	224.7	240.0
32	65.5	90.0	114.5	135.7	156.9	174.2	191.6	207.8	224.1	240.8	257.4
33	70.0	96.0	122.0	144.6	167.2	185.7	204.2	221.6	239.0	257.1	275.2
34	74.4	102.0	129.6	153.6	177.5	197.2	216.9	235.4	253.9	273.4	293.0
35	79.4	108.8	138.2	163.8	189.4	210.5	231.6	251.4	271.3	291.8	312.2

Source: Mesavage, Clement. 1947. Tables for estimating cubic foot volume of timber. U.S. Forest Serv., South. Forest Exp. Sta., Occ. Paper 111.

Form Point Volume Tables

Form point is the percentage relationship that the diameter outside bark at the mid-point of the merchantable length of stem bears to the diameter, breast height, outside bark. Middle diameter is taken at a point half-way between the stump and the utilized top.

Form point, middle-diameter, of second-growth southern pine is as follows:

Dbh	Form point	Mid-diameter
In.	Pct.	In.
6	85	5.1
8	82	5.6
10	79	7.9
12	76	9.1
14	74	10.4

A local volume table may be constructed by determining the average merchantable height and average middle-diameter for trees of each Dbh class. By applying these averages to Huber's formula a local net volume table may be constructed. Huber's formula states that Volume (V) = $(A-\frac{1}{2})\ L$, where $(A-\frac{1}{2})$ is the mid-cross sectional area in square feet, and L is the length of the stick in feet. However, the accuracy of the volume table should be questionable since cubic foot rules do not usually give good results for tree sections greater than 10 to 12 feet in length.

TABLE 42.—Basal area table—gives area of circles in square feet

Diameter	Diameter in tenths of inches									
	0	.1	.2	.3	.4	.5	.6	.7	.8	.9
In.	Area in square feet									
1	0.005	0.007	0.008	0.009	0.011	0.012	0.014	0.016	0.018	0.020
2	.022	.024	.026	.029	.031	.034	.037	.040	.043	.046
3	.049	.052	.056	.059	.063	.067	.071	.075	.079	.083
4	.087	.092	.096	.101	.106	.110	.115	.120	.126	.131
5	.136	.142	.147	.153	.159	.165	.171	.177	.183	.190
6	.196	.203	.210	.217	.223	.230	.238	.245	.252	.260
7	.267	.275	.283	.291	.299	.307	.315	.323	.332	.340
8	.349	.358	.367	.376	.385	.394	.403	.413	.422	.432
9	.442	.452	.462	.472	.482	.492	.503	.513	.524	.535
10	.545	.556	.567	.579	.590	.601	.613	.624	.636	.648
11	.660	.672	.684	.696	.709	.721	.734	.747	.759	.772
12	.785	.799	.812	.825	.839	.852	.866	.880	.894	.908
13	.922	.936	.950	.965	.979	.994	1.009	1.024	1.039	1.054
14	1.069	1.084	1.100	1.115	1.131	1.147	1.163	1.179	1.195	1.211
15	1.227	1.244	1.260	1.277	1.294	1.310	1.327	1.344	1.362	1.379
16	1.396	1.414	1.431	1.449	1.467	1.485	1.503	1.521	1.539	1.558
17	1.576	1.595	1.614	1.632	1.651	1.670	1.689	1.709	1.728	1.748
18	1.767	1.787	1.807	1.827	1.847	1.867	1.887	1.907	1.928	1.948
19	1.969	1.990	2.011	2.032	2.053	2.074	2.095	2.117	2.138	2.160
20	2.182	2.204	2.226	2.248	2.270	2.292	2.315	2.337	2.360	2.382
21	2.405	2.428	2.451	2.474	2.498	2.521	2.545	2.568	2.592	2.616
22	2.640	2.664	2.688	2.712	2.737	2.761	2.786	2.810	2.835	2.860
23	2.885	2.910	2.936	2.961	2.986	3.012	3.038	3.064	3.089	3.115
24	3.142	3.168	3.194	3.221	3.247	3.274	3.301	3.328	3.355	3.382

Topwood Volume—Top Form Index

Top form index, the percentage ratio between the diameter inside bark at the mid-point of the usable top and the scaling diameter of the top sawlog, provides an estimate of the cubic volume, inside bark, obtainable from merchantable tops of sawlog-size southern pines (Table 44). Top form index cannot be accurately measured, but it is represented by the following ocular estimates: 85 percent, high; 75 percent, medium; and 67 percent, low.

TABLE 43.—Merchantable cubic foot volume, inside bark, based on total height[1]

Dbh.	Total tree height							
	30	40	50	60	70	80	90	100
In.	Cubic feet							
	Form classes 65-69, Average 67							
6	2.1	2.5	2.9	3.2	3.7			
8	4.1	4.7	5.6	6.3	7.1	7.8		
10		7.5	8.9	10.2	11.5	12.7	13.8	
12		10.8	12.7	14.5	16.4	17.9	19.9	21.6
14			17.8	20.2	22.6	25.0	27.7	30.1
16			22.7	25.7	28.7	32.1	35.5	38.5
	Form classes 70-74, Average 72							
6	2.3	2.8	3.3	3.7	4.3			
8	4.7	5.5	6.5	7.4	8.2	9.1		
10		8.6	10.2	11.7	13.1	14.6	15.9	
12		12.2	14.5	16.5	18.8	20.6	22.8	24.8
14			20.3	23.1	25.9	28.7	31.8	34.6
16			26.0	29.5	33.1	37.1	41.0	44.6
	Form classes 75-79, Average 77							
6	2.6	3.2	3.8	4.2	4.9			
8	5.2	6.0	7.2	8.2	9.2	10.2		
10		9.6	11.5	13.2	14.8	16.5	18.0	
12		13.8	16.4	18.7	21.4	23.4	26.0	28.4
14			22.8	25.9	29.1	32.2	35.8	38.9
16			29.3	33.3	37.3	41.9	46.4	50.4
	Form classes 80-84, Average 82							
6	2.8	3.5	4.1	4.6	5.3			
8	5.8	6.8	8.1	9.2	10.3	11.4		
10		10.8	12.9	14.8	16.8	18.6	20.3	
12		15.2	18.2	20.7	23.6	25.9	28.8	31.4
14			25.6	29.3	32.9	36.5	40.6	44.2
16			32.7	37.3	41.8	46.9	52.0	56.6
	Form classes 85-89, Average 87							
6	3.2	4.0	4.6	5.2	6.0			
8	6.5	7.6	9.0	10.2	11.5	12.7		
10		11.9	14.3	16.5	18.6	20.7	22.6	
12		17.2	20.5	23.4	26.7	29.3	32.6	35.5
14			28.4	32.4	36.4	40.5	45.0	49.0
16			36.4	41.5	46.6	52.3	58.0	63.1

[1] Compiled from Minor's (1950) form class volume tables.

Source: Burns, Paul Y. 1965. A condensation of Minor's form class volume tables for southern pine pulpwood. La. Agr. Exp. Sta., LSU Forestry Note 61.

Pulpwood Volume Tables

Cubic volume determinations by Hawes (1940), based on merchantable height and average top diameters of 5 inches outside bark, were found to be consistent with current cubic volume measures of southern pine pulpwood. To use Tables 45, 46, and 47, tally the number of trees by Dbh and merchan-

TABLE 44.—Gross cubic foot volume, inside bark, in merchantable tops of sawlog-size southern pines

Scaling diameter of top sawlog	Length of merchantable top in feet										
	4	8	12	16	20	24	28	32	36	40	44
In.	Cubic feet										
	Top form index 85										
5	0.4	0.8	1.2	1.5	1.9	2.3	2.7	3.1	3.5	3.8	4.2
6	.6	1.1	1.7	2.3	2.8	3.4	4.0	4.5	5.1	5.7	6.2
7	.8	1.6	2.4	3.1	3.9	4.7	5.5	6.5	7.1	7.9	8.6
8	1.0	2.0	3.0	4.0	5.0	6.1	7.1	8.1	9.1	10.1	11.1
9	1.3	2.5	3.8	5.0	6.5	7.6	8.8	10.1	11.3	12.6	13.9
10	1.6	3.2	4.7	6.3	7.9	9.5	11.0	12.6	14.2	15.8	17.3
11	1.9	3.9	5.8	7.7	9.6	11.6	13.5	15.4	17.3	19.3	21.2
12	2.3	4.5	6.8	9.1	11.4	13.6	15.9	18.2	20.4	22.7	25.0
13	2.6	5.3	7.9	10.6	13.2	15.8	18.5	21.1	23.8	26.4	29.0
14	3.1	6.2	9.3	12.4	15.4	18.5	21.6	24.7	27.8	30.9	34.0
15	3.6	7.1	10.7	14.3	17.9	21.4	25.0	28.6	32.2	35.7	39.3
16	4.0	8.1	12.1	16.1	20.2	24.2	28.2	32.3	36.3	40.4	44.4
17	4.5	9.0	13.6	18.1	22.6	27.1	31.7	36.2	40.7	45.2	49.8
18	5.1	10.2	15.3	20.4	25.5	30.6	35.8	40.9	46.0	51.1	56.2
19	5.7	11.5	17.2	22.9	28.6	34.4	40.1	45.8	51.5	57.3	63.0
20	6.3	12.6	18.9	25.2	31.5	37.8	44.1	50.4	56.7	63.1	69.4
	Top form index 75										
8	0.8	1.6	2.4	3.1	3.9	4.7	5.5	6.3	7.1	7.9	8.6
9	1.0	2.0	3.0	4.0	5.0	6.1	7.1	8.1	9.1	10.1	11.1
10	1.2	2.5	3.7	4.9	6.1	7.4	8.6	9.8	11.0	12.3	13.5
11	1.5	3.0	4.5	6.0	7.5	9.0	10.5	12.0	13.5	15.0	16.5
12	1.8	3.5	5.3	7.1	8.8	10.6	12.4	14.1	15.9	17.7	19.4
13	2.1	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.0	23.0
14	2.4	4.8	7.2	9.6	12.0	14.4	16.8	19.2	21.6	24.1	26.5
15	2.8	5.6	8.4	11.1	13.9	16.7	19.5	22.3	25.1	27.9	26.3
16	3.1	6.3	9.4	12.6	15.7	18.8	22.0	25.1	28.3	31.4	34.6
17	3.6	7.1	10.7	14.3	17.9	21.4	25.0	28.6	32.2	35.7	39.3
18	4.0	8.0	11.9	15.9	19.9	23.9	27.8	31.8	35.8	39.8	43.7
19	4.5	8.9	13.4	17.8	22.3	26.8	31.2	35.7	40.2	44.6	49.1
20	4.9	9.8	14.7	19.6	24.5	29.5	34.4	39.3	44.2	49.1	54.0
	Top form index 67										
11	1.2	2.4	3.6	4.8	6.0	7.2	8.4	9.6	10.8	12.0	13.2
12	1.4	2.8	4.2	5.6	7.0	8.4	9.8	11.2	12.6	14.0	15.4
13	1.7	3.3	5.0	6.6	8.3	9.9	11.6	13.2	14.9	16.5	18.2
14	1.9	3.9	5.8	7.7	9.6	11.6	13.5	15.4	17.4	19.3	21.2
15	2.2	4.4	6.5	8.7	10.9	13.1	15.3	17.4	19.6	21.8	24.0
16	2.5	5.0	7.5	10.0	12.5	15.0	17.5	20.0	22.5	25.0	27.5
17	2.8	5.7	8.5	11.3	14.2	17.0	19.9	22.7	25.5	28.4	31.2
18	3.2	6.4	9.6	12.8	16.0	19.2	22.4	25.6	28.8	32.0	35.2
19	3.5	7.0	10.6	14.1	17.6	21.1	24.6	28.2	31.7	35.2	38.7
20	3.9	7.8	11.7	15.7	19.6	23.5	27.4	31.3	35.2	39.2	45.1

Source: Mesavage, Clement. 1947. Tables for estimating cubic foot volume of timber. U.S. Forest Serv., South. Forest Exp. Sta., Occ. Paper 111.

TABLE 45.—Cubic foot volume, including bark, for stands of southern pine that are above average form[1]

Form point	Dbh	Merchantable length of stem in feet														Mid-diameter
		12	16	20	24	28	32	36	40	44	48	52	56	60	64	
Pct.	In.	Cubic feet														In.
85	6	1.7	2.3	2.8	3.4	4.0	4.5	5.1								5.1
83	8		3.8	4.8	5.8	6.7	7.7	8.7	9.6	10.6	11.6					6.7
81	10			7.2	8.6	10.0	11.4	12.9	14.3	15.7	17.2	18.6	20.0	21.5		8.1
79	12				11.8	13.7	15.7	17.6	19.6	21.6	23.5	25.5	27.4	29.4	31.4	9.5
77	14					17.7	20.3	22.8	25.3	27.9	30.4	32.9	35.5	38.0	40.5	10.8
75	16						25.1	28.3	31.4	34.5	37.7	40.8	43.9	47.1	50.2	12.0

TABLE 46.—Cubic foot volume, including bark, for stands of southern pine that are of average form[1]

Form point	Dbh	Merchantable length of stem in feet														Mid-diameter
		12	16	20	24	28	32	36	40	44	48	52	56	60	64	
Pct.	In.	Cubic feet														In.
83	6	1.6	2.2	2.7	3.2	3.8	4.3	4.8								4.95
81	8		3.6	4.6	5.5	6.4	7.3	8.3	9.1	10.1	11.0					6.50
79	10			6.8	8.2	9.5	10.8	12.3	13.6	14.9	16.3	17.7	19.0	20.4		7.92
77	12				11.2	13.0	14.9	16.7	18.6	20.5	22.3	24.2	26.0	27.9	29.8	9.23
75	14					16.8	19.3	21.7	24.0	26.5	28.9	31.3	33.7	36.1	38.5	10.51
73	16						23.8	26.9	29.8	32.8	35.8	38.8	41.7	44.7	47.7	11.71

TABLE 47.—Cubic foot volume, including bark, for stands of southern pine that are below average form[1]

Form point	Dbh	Merchantable length of stem in feet														Mid-diameter
		12	16	20	24	28	32	36	40	44	48	52	56	60	64	
Pct.	In.	Cubic feet														In.
81	6	1.6	2.1	2.6	3.1	3.7	4.2	4.7								4.9
79	8		3.5	4.3	5.2	6.0	6.9	7.8	8.6	9.5	10.4					6.3
77	10			6.5	7.8	9.0	10.3	11.6	12.9	14.2	15.5	16.8	18.1	19.4		7.7
75	12				10.6	12.4	14.1	15.9	17.7	19.4	21.2	23.0	24.8	26.5	28.3	9.0
73	14					15.9	18.1	20.4	22.7	24.9	27.2	29.5	31.8	24.0	36.3	10.2
71	16						22.7	25.5	28.4	31.2	34.0	36.9	39.7	42.5	45.4	11.4

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[1] Top utilization, 5 inches outside bark, Tables 45, 46, and 47, varies from 3.8 to 6 inches.

Source for Tables 45, 46, and 47: Hawes, E. T. 1940. Volume tables, converting factors, and other information applicable to commercial timber in the South. 3rd. Ed., U.S. Forest Serv., Div. of State and Private Forestry, Atlanta.

table height class, sum the number of trees per block, and multiply by the cubic volume for that block. Sum the rows to obtain cubic volume of pulpwood by diameter and form point classes.

To convert cubic volumes to cord volume, refer to the appropriate converting table under the cord volume section.

An early study by MacKinney and Chaiken (1939) produced a volume table for loblolly pine. Table 48, based on Dbh and total height measurements, gives merchantable cubic volume, inside bark. The table finds much usage in woodlands management throughout the South, and when restricted to application in the coastal plain, the cubic volume data are representative of current growing stock.

Aerial Photographs

Minor (1953b) developed a cubic foot volume table for use with aerial photographs for rough estimates of southern pine in all-aged and in low-density even-aged sawlog stands, assuming that form class averages 80 percent (Table 49). Volume adjustments can be made for different form classes by the application of the form class correction factor.

TABLE 48.—Cubic foot volume, inside bark, to a 4.0-inch top diameter, outside bark, for second-growth loblolly pine[1]

Dbh	Total tree height in feet								
	20	30	40	50	60	70	80	90	100
In.	Cubic feet								
5	0.46	0.80	1.28	1.77	2.36	3.01	3.59		
6	.74	1.32	2.08	2.96	3.76	4.55	5.37		
7	1.07	2.06	3.17	4.22	5.29	6.37	7.48	8.63	
8	1.57	2.96	4.30	5.66	7.06	8.48	9.94	11.40	
9	2.20	3.91	5.56	7.30	9.07	10.86	12.71	14.53	
10		4.92	6.99	9.12	11.29	13.51	15.73	17.96	
11		6.07	8.56	11.13	13.76	16.42	19.07	21.80	24.54
12		7.32	10.41	13.33	16.42	19.55	22.70	25.94	29.25
13		8.66	12.15	15.71	19.28	22.98	26.70	30.47	34.20
14		10.12	14.16	18.21	22.39	26.65	30.95	35.23	39.55
15			16.28	20.93	25.74	30.60	35.42	40.86	45.87
16			18.51	23.88	29.32	34.71	40.72	46.36	52.96
17			20.93	26.97	33.00	39.18	45.87	53.10	59.62
18				30.21	36.90	44.30	52.18	59.38	66.66
19				33.58	41.56	49.43	58.01	65.99	74.09
20				37.13	45.96	55.39	64.13	72.97	81.91

[1] Trees selected from 32 stands in the coastal plain of North Carolina and South Carolina. Volume includes peeled stem above a 0.7-foot stump height.

Source: MacKinney, A. L., and L. E. Chaiken. 1939. Volume, yield, and growth of loblolly pine in the Mid-Atlantic coastal region. U.S. Forest Serv., Appalachian Forest Exp. Sta., Tech. Note 33.

TABLE 49.—Cubic foot volume table for use with aerial photographs [1]

Crown diameter	Total visible height in feet						
	50	60	70	80	90	100	110
Ft.	Cubic feet						
10	10.9	13.0	15.2	17.4	19.6		
12	13.3	17.0	18.5	21.1	24.1	26.7	
14	16.3	19.7	22.7	26.0	29.3	32.7	36.0
16		22.6	26.2	30.0	33.8	37.6	41.5
18		26.2	30.5	34.9	39.5	43.8	48.1
20		30.0	35.0	40.0	45.0	50.0	55.0
22		34.5	40.2	46.0	51.9	57.6	63.3
24			45.7	52.3	58.9	65.4	72.0
26			50.2	57.4	64.7	71.9	79.2
28			55.9	63.9	72.0	80.0	88.0
30			61.8	70.6	79.4	88.2	97.1

[1] Volume in cubic feet of solid wood, inside bark. Table may be used for rough estimates of southern pine (other than longleaf) in all-aged or low-density even-aged sawlog stands, assuming that form class averages 80.

Source: Minor, Charles O. 1953b. Preliminary volume tables for use with aerial photographs. Forest Farmer 12(10). 9-10, 11.

Log Grade-Lumber Yields

Log grading is the estimation of the proportion of various lumber grades or qualities of veneer stock that a given log will yield, and the classification of that log into a grade for which the minimum requirements have been met.

Green lumber yields, combined for slash and longleaf and for loblolly and shortleaf pine, are presented in Tables 50 and 51, respectively. Values are the result of six studies conducted throughout the South (Campbell, 1962). So few slash and longleaf logs over 17 inches were found in these studies that no yield table for grade 1 logs was developed. Because the results are regional averages, it is unlikely that they will be comparable to yields of any single mill.

Other studies have produced estimates of board width recovery from logs and trees of different diameters. Table 52 shows board widths that may be recovered from trees of varying Dbh class, and Table 53 shows the width percentages recoverable from logs by scaling diameter. If the dimensions of a board are known, the actual board foot content may be calculated from Table 54.

The following are the U.S. Forest Service (1962) procedures and specifications for grading southern pine logs:

Southern pine logs are graded in two steps. First they are given a tentative grade based on diameter and K count (see definition); secondly, they are given a final grade after consideration of other degrading factors.

Step I. Determine D and K count on all four sides. Establish tentative grades according to the following table:

Grade	Minimum scaling diameter (D)	Maximum knot count (K)
	In.	
1	17 (14)	D/5
2	10	D/2
3	5	no limit
4	5	no limit

Step II. In the sequence listed, determine:

1. Sweep: Degrade any tentative 1, 2, or 3 grade log one grade if sweep is at least 3 inches and equals or exceeds D/3. (This is the final grade if the log has no evidence of heart rot and no unsound or oversize knots.)
2. Heart rot: Degrade any tentative 1, 2, or 3 grade log one grade if conk, massed hyphae, or other evidence of advanced heart rot is present. (This is the final grade if the log has no unsound or oversize knots.)
3. Unsound or oversize knots: Degrade any tentative grade 3 log to grade 4 if unsound or oversize log knots are dispersed to the extent that they cannot be contained in one quarter face.

The following definitions explain grading terminology:

TABLE 50.—Green lumber yields for slash and longleaf pine logs

Scaling diameter	Lumber grades										
	B&B	C	D	1C	1D	2C	2D	3C	3D	4C	4D
In.	Percent										
					Log Grade II						
10	9	22	25	6	25	8	3	2	0	0	0
11	11	22	24	6	23	9	3	2	0	0	0
12	14	21	23	5	22	10	3	2	0	0	0
13	17	20	22	5	21	11	2	2	0	0	0
14	20	20	21	5	19	12	1	2	0	0	0
15	22	20	20	4	17	14	1	2	0	0	0
16	25	18	19	5	22	11	2	2	0	0	0
Average	17	20	21	5	22	11	2	2	0	0	0
					Log Grade III						
6	1	6	9	3	32	30	18	1	0	0	0
7	1	7	10	3	30	31	17	1	0	0	0
8	2	7	11	3	27	33	16	1	0	0	0
9	2	8	12	3	25	34	15	1	0	0	0
10	3	8	14	3	22	35	14	1	0	0	0
11	3	9	15	3	20	36	13	1	0	0	0
12	4	9	16	3	17	38	12	1	0	0	0
13	4	10	17	3	15	40	10	1	0	0	0
14	5	10	18	3	12	42	9	1	0	0	0
15	5	11	19	3	10	43	8	1	0	0	0
16	6	11	21	3	7	44	7	1	0	0	0
Average	4	9	14	3	18	39	12	1	0	0	0
					Log Grade IV						
6	0	1	2	1	10	43	38	0	5	0	0
7	0	1	2	1	9	47	35	0	5	0	0
8	0	1	2	1	9	50	32	0	5	0	0
9	0	1	2	1	8	53	29	1	5	0	0
10	0	1	2	1	7	57	26	1	5	0	0
11	0	1	2	1	6	60	23	2	5	0	0
12	0	1	2	1	6	65	18	2	5	0	0
13	0	1	2	1	5	70	14	2	5	0	0
14	0	1	2	1	4	73	11	3	5	0	0
15	0	1	2	1	4	77	7	3	5	0	0
16	0	1	2	1	3	80	4	4	5	0	0
Average	0	1	2	1	7	57	25	2	5	0	0

Source: Campbell, Robert A. 1962. Southern pine lumber grade yields. U.S. Forest Serv., Southeast. Forest Exp. Sta., Res. Note 182.

1. K count: A numerical log knot factor used in association with log diameter for placing a log in its tentative grade. It is the number of visible overgrown log knots, plus the sum of average diameters of sound log knots, plus twice the sum of the average diameters of unsound log knots.
2. Overgrown knots: Branch or stub indicated by a surface bump or disturbance of bark pattern.
3. Sound knot: Visible branch, stub, or socket without advanced decay extending to heart, or hole larger than ¼ inch that penetrates more than 2 inches.
4. Unsound knot: Visible branch, stub, or socket not conforming to definition of sound knot.
5. Bad knot: Unsound knot, or visible knot larger than ⅙ the average dib at the small end of the log.
6. Sweep: Greatest deviation of log axis from straight line connecting centers of each end. Measure to nearest whole inch at point of greatest deviation.
7. Oversize knot: Any sound log knot with diameter larger than D/6.

TABLE 51.—Green lumber yields for loblolly and shortleaf pine logs

Scaling diameter	Lumber grades										
	B&B	D	D	1C	1D	2C	2D	3C	3D	4C	4D
In.	Percent										
	Log Grade I										
17	22	8	5	13	18	15	9	6	4	0	0
18	24	8	4	14	17	15	8	6	4	0	0
19	25	8	3	15	15	16	7	7	4	0	0
20	26	8	3	16	14	16	6	7	4	0	0
21	27	8	2	17	12	17	5	8	4	0	0
22	28	8	2	18	11	17	4	8	4	0	0
23	30	8	1	19	8	18	3	9	4	0	0
24	31	8	1	20	7	18	2	9	4	0	0
25	32	8	0	21	5	19	1	10	4	0	0
26	34	8	0	22	3	19	0	10	4	0	0
Average	25	8	3	17	12	17	6	8	4	0	0
	Log Grade II										
10	20	11	15	5	25	11	8	1	3	1	0
11	20	10	14	6	25	12	8	1	3	1	0
12	19	10	13	7	24	13	8	2	3	1	0
13	19	10	12	8	24	13	8	2	3	1	0
14	18	9	11	9	24	14	8	3	3	1	0
15	18	9	10	10	23	14	8	4	3	1	0
16	18	9	9	11	23	14	8	4	3	1	0
17	17	9	8	12	23	14	8	5	3	1	0
18	17	8	7	13	22	15	8	6	3	1	0
19	16	8	6	14	22	16	8	6	3	1	0
20	16	8	5	14	21	17	8	7	3	1	0
21	16	8	4	15	21	17	8	7	3	1	0
22	15	7	3	16	21	18	8	8	3	1	0
23	15	7	2	17	20	19	8	8	3	1	0
24	14	7	1	18	20	19	8	9	3	1	0
Average	17	9	8	11	23	15	8	5	3	1	0

(Continued)

TABLE 51.—(Continued)

Scaling diameter	Lumber grades										
	B&B	D	D	1C	1D	2C	2D	3C	3D	4C	4D
In.	Percent										
	Log Grade III										
6	1	3	0	4	46	8	28	3	6	1	0
7	1	3	1	4	43	10	28	3	6	1	0
8	2	3	1	4	40	12	28	3	6	1	0
9	2	3	2	4	37	14	28	3	6	1	0
10	3	3	2	4	34	16	28	3	6	1	0
11	3	3	3	4	31	18	28	3	6	1	0
12	4	3	3	4	28	20	28	3	6	1	0
13	4	3	4	4	25	22	28	3	6	1	0
14	5	3	4	4	22	24	28	3	6	1	0
15	5	3	5	4	19	26	28	3	6	1	0
16	6	3	6	4	16	27	28	3	6	1	0
17	6	3	7	4	13	29	28	3	6	1	0
18	6	3	8	4	10	31	28	3	6	1	0
19	7	3	8	4	7	33	28	3	6	1	0
20+	7	3	9	4	4	35	28	3	6	1	0
Average	5	3	6	4	21	23	28	3	6	1	0
	Log Grade IV										
6	1	1	1	1	6	26	38	4	21	0	1
7	1	1	1	1	6	26	37	5	21	0	1
8	1	1	1	1	5	26	37	6	21	0	1
9	1	1	1	1	5	26	36	7	21	0	1
10	1	1	1	1	4	26	36	8	21	0	1
11	1	1	1	1	4	26	35	8	21	1	1
12	1	1	1	1	3	26	35	9	21	1	1
13	1	1	1	1	3	26	34	9	21	2	1
14	1	1	1	1	2	26	34	10	21	2	1
15	1	1	1	1	2	26	32	11	21	3	1
16	1	1	1	1	2	26	32	11	21	3	1
17	1	1	1	1	1	26	31	12	21	4	1
18	1	1	1	1	1	26	31	12	21	4	1
19	1	1	1	1	0	26	30	13	21	5	1
20+	1	1	1	1	0	26	30	13	21	5	1
Average	1	1	1	1	3	26	32	11	21	2	1

Source: Campbell, Robert A. 1962. Southern pine lumber grade yields. U.S. Forest Serv., Southeast. Forest Exp. Sta., Res. Note 182.

TABLE 52.—Estimation of board width from scaling diameter for 1-inch stock[1]

Scaling diameter	Board width in inches				
	4	6	8	10	12
In.	Percent				
6	100				
7	90	10			
8	43	57			
9	31	69			
10	25	64	11		
11	15	41	44		
12	11	24	65		
13	7	22	63	8	
14	4	17	35	42	2
15	4	14	22	53	8
16	3	11	17	44	25
17	3	7	15	21	55
18	3	7	13	16	62
19	2	5	11	14	67
20	1	5	9	15	70
21	1	5	8	14	72
22	1	5	9	14	71

[1] Values are in percent of board width of rough green lumber sawn from pine logs by circular mills. The data agree with a later study by Applefield (1958).

Source: McClay, T. A. 1954. Lumber grade yields in the loblolly-shortleaf pine type by the southern pine log grades. U.S. Forest Serv., Southeast. Forest Exp. Sta., Sta. Paper 37.

TABLE 53.—Estimation of board width from dbh for 1-inch stock[1]

Dbh	Board width in inches					
	4	5	6	8	10	12
In.	Percent					
10	28	18	52	2		
12	18	11	54	17		
14	10	5	37	43	5	
16	7	3	27	37	26	
18	5	2	21	28	40	4
20	3	1	16	19	38	23
22	2	1	12	16	34	35
24	2	1	8	13	21	55

[1] Values are in percent of board width of rough green lumber sawn from loblolly and shortleaf pine trees of different diameters.

Source: McClay, T. A. 1953. Estimating board widths obtainable from pine trees of different diameters. U.S. Forest Serv., Southeast. Forest Exp. Sta., Res. Note 25.

TABLE 54.—Lumber scale, contents in board feet

Dimensions of cross-section	Board length in feet					
	6	8	10	12	14	16
In.	Board feet					
1 x 3	1.5	2	2.5	3	3.5	4
1 x 4	2	2.6	3.3	4	4.6	5.3
1 x 5	2.5	3.3	4	5	6	6.6
1 x 6	3	4	5	6	7	8
1 x 7	3.5	4.6	6	7	8	9.3
1 x 8	4	5.3	6.6	8	9.3	10.6
1 x 10	5	6.6	8.3	10	11.6	13.3
1 x 12	6	8	10	12	14	16
2 x 4	4	5.3	6.6	8	9.3	10.6
2 x 6	6	8	10	12	14	16
2 x 8	8	10.6	13.3	16	18.6	21.3
2 x 10	10	13.3	16.6	20	23.3	26.6
2 x 12	12	16	20	24	28	32
2 x 14	14	18.6	23.3	28	32.6	37.3
3 x 6	9	12	15	18	21	24
3 x 8	12	16	20	24	28	32
3 x 10	15	20	25	30	35	40
3 x 12	18	24	30	36	42	48
4 x 4	8	10.6	13.3	16	18.6	21.3
6 x 6	18	24	30	36	42	48

Weight Factors

Weight is a universal measure for buying and selling bulk products, but it has only recently been applied to the forest products industry. These recent applications prove that many southern pine forest products may be accurately, rapidly, and efficiently scaled by weight. Grading wood quality by weight, however, has yet to be developed.

Weight of forest products is considered under three headings: (1) Weight of pulpwood, lumber, and sawtimber; (2) Methods of establishing weight scales; (3) Weight inventory as a management tool.

Pulpwood Weights

Weights for a cord of wood vary from locale to locale, principally because of the differences in wood density and moisture content. Loblolly-shortleaf and longleaf-slash pine groups make up the two types with contrasting weights, longleaf-slash pine being the heavier as a result of higher wood specific gravity.

The following are average estimated weights per 168-cubic foot cord for the major pine type groups:

Type	Green weight per cord
	Lbs.
Loblolly-shortleaf	
Texas to W. Louisiana	4700
Cen. Louisiana through the Southeast	5200
Longleaf-slash	5550

To demonstrate the extreme variation in wood weights throughout the southern range, Figure 3 shows the comparison of pulpwood weights in pounds per cord (168 cubic feet) by geographic location. Weights shown are either those used for purchasing pulpwood or those values that were obtained through operational weight studies.

Based on 16,000 cords of loblolly-shortleaf pine pulpwood received at one Mississippi mill, average oven-dry density was 30 pounds per cubic foot. At this mill, there has been an increase in basic wood density over the past 10-year period.

Based on 34 truckloads scaled at one mill, dry density varied in pulpwood bolts from different bole positions as follows:

Position	Oven-dry weight
	Lbs./Cu. Ft.
Topwood	28.04
Bolewood	28.80
Buttwood	33.20

Lumber Weights

Estimated lumber weights on all standard items of southern pine species are included in the Standard Grading Rules for Southern Pine Lumber (1963) published by the Southern Pine Inspection Bureau. These are not actual weights but are used in computing delivered prices for lumber in freight movements which base the transportation charges on actual lumber weights. The estimated weights are normally more than actual weights, except for battens and mouldings, which are sold on 100-foot linear measure, and for lath and pickets, which are sold in lots of 1,000 pieces. The board measure of dressed lumber is based on the corresponding dimensions of rough green lumber (Table 55).

Sawtimber Weights

Data from a study by Page and Bois (1961), Table 56, show the weights of logs, by scaling diameter, required to produce one MBF of lumber for four species. The effect of log length on weight-yield ratios was negligible, and the data are consistent with results of other studies: Bower (1962); Lange (1962); Siegel and Row (1960); and Freeman (1962).

Green weights of logs, lumber, chips, and residue per MBF of lumber produced for southern pine are shown in Table 57. Results of the study are consistent with findings throughout the South.

Methods of Establishing Weight Scales

Gross Log Weight—Sales have been conducted on a limited basis using a single converting factor of weight per MBF, log scale. Gross log weight per truckload divided by the converting factor equals board feet per truckload. Such factors are restricted to stands of uniform timber types, and no allowances are made for defect. Erroneous volumes may appear if such factors are applied outside the region for which they were prepared. The figures shown in Table 58 are average and range values derived from actual weights used in many timber sales throughout the Southeast.

By simultaneously scaling and weighing truckloads of logs from a sample area, similar weight factors can be constructed for local application throughout the region.

Most studies confirm that logs from wet sites weigh more than wood of the same species from dry sites.

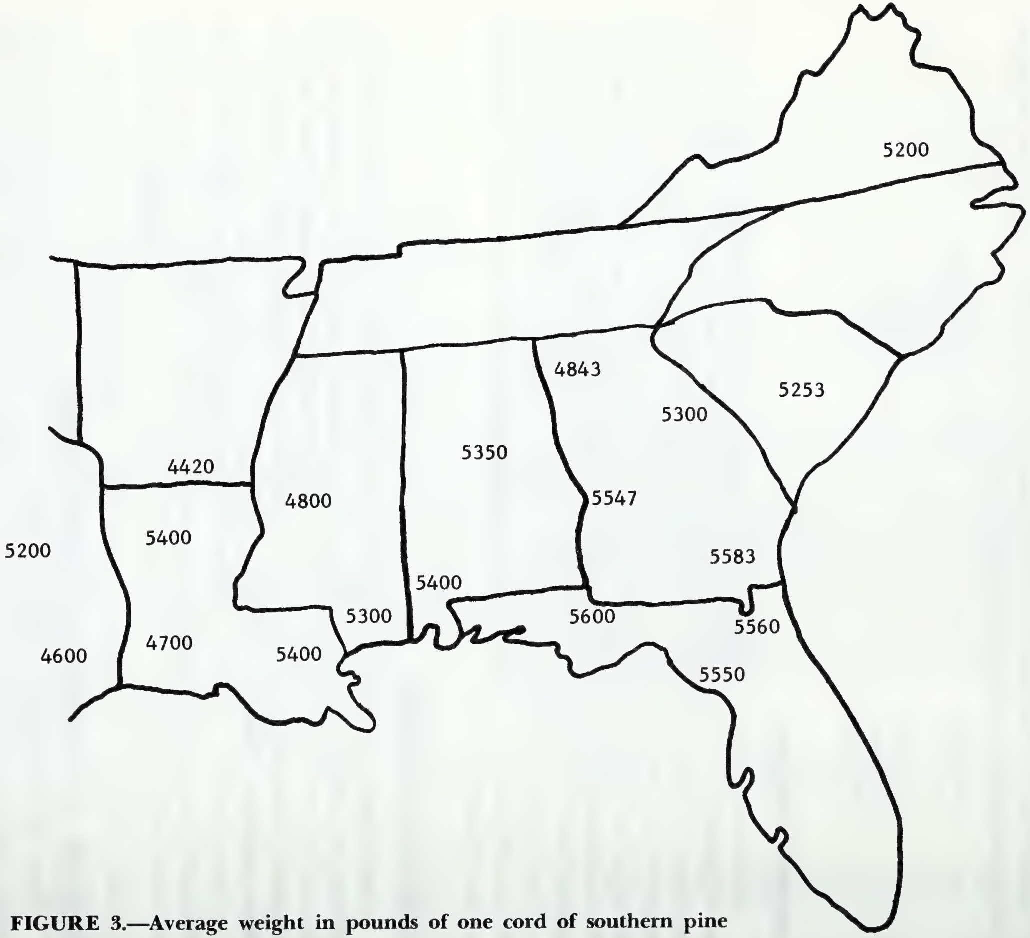

FIGURE 3.—Average weight in pounds of one cord of southern pine pulpwood by geographic location.

TABLE 55.—Average weights of southern pine lumber items

Dimensions In.	Longleaf Lbs.	Shortleaf Lbs.
Flooring		
1 x 3	2000	1800
1 x 4 (For hollow back deduct 100 lbs.)	2100	1900
1¼ x 3	2200	2000
1¼ x 4	2300	2100
Drop Siding		
1 x 6 (Pats. 116 and 121)	2000	2000
1 x 8 and 10 (Pats. 116 and 121)	2100	2100
1 x 6 (Pat. 117)	1700	1700
1 x 8 and 10 (Pat. 117)	1800	1800
1 x 6 (other patterns)	1800	1800
1 x 8 and 10 (other patterns)	1900	1900
Bevel and SE Siding for 1 in.	1100	1000
Bevel and SE Siding for 1¼ in.	1400	1300
Finish		
1 x 2 to 1 x 10 S1S or S2S 25/32 in.	2600	2500
1 x 2 to 1 x 10 S3S or S4S 25/32	2500	2400
1¼ x 2 to 2 x 10 S1S or S2S	2900	2800
1¼ x 2 to 2 x 10 S3S or S4S	2800	2700
1 x 2 to 2 x 10 Rough	3400	3200
Strips and Boards		
1 x 2 to 1 x 10 S1S or S2S 25/32 in.	2700	2500
1 x 12 S1S or S2S 25/32 in.	2800	2600
1 x 2 to 1 x 10 S3S or S4S 25/32 in.	2600	2400
1 x 12 S3S or S4S 25/32 in.	2700	2500
1 x 2 to 1 x 4 D & M	2100	1900
1 x 6 D & M or Shiplap	2400	2200
1 x 8 to 1 x 10 D & M or Shiplap	2500	2300
1 x 2 to 1 x 10 Rough	3400	3200
1 x 12 Rough	3500	3300
2 x 2 to 2 x 8 Rough	3400	3300
2 x 10 to 2 x 12 Rough	3500	3400
2 x 2 to 2 x 8 Dressed to 1⅝ in.	2700	2500
2 x 10 & 2 x 12 Dressed to 1⅝ in.	2800	2600
For 1¾ in. add	400	400
For D&M, SL & Gr. for Splines, deduct	200	200
2 x 4 to 2 x 12 Rough green	4500	4500
2 x 4 to 2 x 12 Green, dressed 1⅝ in.	2800	2600
Heavy Joists, Timbers, etc. (over 2 in. thick)		
Rough, green	4500	4500
S4S ¼-in. scant, green	4200	4200
S4S ⅜ in. scant, green	4000	4000
S4S ½ in. scant, green	3800	3800
T & G—S2S & SL and S2S & CG2E, deduct	300	300
Car Siding, Lining and Roofing		
1 x 4 & 1 x 6 T & G 13/16 in.	2200	2200
1 x 4 & 1 x 6 S2S 13/16 in.	2600	2600
For 25/32 in. deduct	100	100
Car Decking		
2 x 6 to 3 x 8 S2S dry	3200	3000
2 x 6 to 3 x 8 S2S green	4200	4200
2 x 6 to 3 x 8 rough dry	3600	3400
2 x 6 to 3 x 8 rough green	4500	4500

Source: Southern Pine Inspection Bureau. 1963. Standard grading rules for southern pine lumber. New Orleans.

TABLE 56.—Weight of logs required to produce one MBF lumber[1] [2]

Scaling diameter	Green weight of logs by species		
	Loblolly and Shortleaf	Longleaf	Slash
In.	Pounds		
5	19,400	20,000	23,600
6	14,100	16,300	19,000
7	12,900	14,500	16,800
8	11,900	13,500	15,200
9	11,300	12,800	14,200
10	10,900	12,200	13,400
11	10,500	11,800	12,800
12	10,200	11,400	12,400
13	9,900	11,200	11,900
14	9,800	11,000	11,600
15	9,600	10,900	11,300
16	9,400	10,800	11,000
Average weight	10,759	13,087	14,191

[1] Values obtained were read from tables of averages.

[2] Green weight of logs includes weight of bark.

Source: Page, Rufus H., and Paul J. Bois. 1961. Buying and selling southern yellow pine sawlogs by weight. Georgia Forest Res. Council Rpt. 7.

TABLE 57.—Green weight of logs, lumber, pulp chips, and sawmill residues per thousand board feet of lumber from southern yellow pine, by size of log

Scaling diameter	Lumber	Residue chips	Sawdust & unused residues	Peeled log	Bark	Unpeeled log
In.	Pounds					
6	4580	5540	4810	14,930	2010	16,940
7	5420	4600	4200	14,220	1900	16,120
8	5770	3900	3810	13,480	1760	15,240
9	5880	3340	3640	12,860	1630	14,490
10	5900	2940	3540	12,380	1550	13,930
11	5860	2600	3440	11,900	1440	13,340
12	5780	2320	3410	11,510	1350	12,860
13	5700	2100	3380	11,180	1210	12,440
14	5670	1900	3430	11,000	1210	12,210
15	5580	1740	3420	10,740	1120	11,860

Source: Applefield, Milton. 1958. The marginal sawlog for southern yellow pine. Texas Forest Serv. Res. Note 21.

TABLE 58.—Weight per MBF Scribner Decimal C log rule by species

Species	Average weight per MBF[1]	Range[1]
	Lbs.	Lbs.
Longleaf	15,500	14,215 - 18,150
Longleaf-loblolly	15,000	
Loblolly	14,900	
Slash	15,100	12,984 - 16,336
Slash-longleaf	15,100	13,136 - 16,564
Slash, pond, loblolly, longleaf	15,400	14,017 - 15,953
Shortleaf	14,700	
Pond	13,770	
Slash-loblolly	14,900	14,097 - 16,090

[1] Average and range values were derived from many weight sales, and they have been used for actual weight scaling in Southeastern Georgia.

Source: U.S. Army Corps of Engineers. 1965. Selling sawtimber by the pound. Unpublished study.

Log Count and Truckload Weight—Weight scaling studies have confirmed that small-diameter logs weigh more per MBF than logs of larger diameter. The effect of diameter is most pronounced when the Doyle rule is used as a basis for weight scaling, whereas the International rule can be readily and accurately adapted to a system of weight scaling using a single converting factor.

Figures by Page and Bois (1961), Table 59, show weight variations resulting from the application of different log scales. Freeman (1962) and Bair (1965) developed formulae which stated that as weight per truckload increased, volume increased, and as number of logs per truckload increased, volume decreased. Tables 60 and 61 give board foot volumes in Doyle and in Doyle-Scribner rules, respectively. Used in Central Louisiana and East Texas, these tables allow no more error than that expected with stick scaling. There is no practical difference between the Doyle and the Doyle-Scribner rule (Table 30).

Weight Scaling by Diameter and Log Length—The most successful weight scales to date have been those making corrections for diameter class and log

TABLE 59.—Average weight of one MBF of lumber and one MBF of logs by three log rules[1]

Species	Lumber volume	Doyle rule	Scribner Decimal C rule	International rule
	Pounds			
Loblolly	10,890	17,754	12,801	11,013
Shortleaf	10,796	17,917	12,655	10,866
Longleaf	13,087	24,227	14,350	12,240
Slash	14,191	23,856	14,989	12,729

[1] Log and lumber weights given in the green condition.

Source: Page, Rufus H., and Paul J. Bois. 1961. Buying and selling southern yellow pine sawlogs by weight. Georgia Forest Res. Council Rpt. 7.

TABLE 60.—Board feet, Doyle log scale, in a truck load as related to weight of load and number of logs

Number of logs	Total weight of logs in thousands of pounds										
	25	26	27	28	29	30	31	32	33	34	35
	Total board feet, gross Doyle scale										
30	1590										
31	1590	1670									
32	1560	1640	1730								
33	1550	1640	1730	1810							
34	1540	1600	1690	1780	1860						
35	1500	1590	1680	1770	1860						
36	1490	1570	1660	1760	1850	1910					
37	1480	1550	1650	1740	1800	1900	2000				
38	1470	1530	1630	1720	1790	1890	1980	2050			
39		1540	1600	1700	1770	1870	1950	2040	2140		
40			1610	1680	1750	1850	1940	2020	2090	2190	
41				1650	1750	1820	1930	2000	2070	2180	2250
42				1660	1730	1800	1900	1980	2080	2160	2230
43					1700	1800	1880	1950	2060	2130	2210
44						1770	1850	1960	2030	2110	2220
45						1770	1850	1930	2000	2120	2190

Source: Freeman, E. A. 1962. Weight-scaling sawlog volume by the truckload. Forest Prod. Jour. 12.473-475.

length on log weight. Tables 62 and 63, published by Barton (1966) are workable examples of how these scales can be conducted. Steps in the use of these tables are as follows:

1. Determine the weight of the load of logs.
2. Count the number of logs on the load.
3. Determine the length class under which the load is to be categorized.
4. Divide the number of logs into the net weight and obtain the average weight per log.
5. With the average length and weight, refer to Table 63 and determine the average diameter class.
6. With the average diameter and average length, refer to the converting

TABLE 61.—Board feet, Doyle-Scribner log scale, in a truck load as related to weight of load and number of logs

Number of logs	Total weight of logs in thousands of pounds: 37	38	39	40	41	42
	Total board feet, gross Doyle-Scribner scale					
35	2560	2650	2750	2850	2950	3050
36	2530	2620	2720	2820	2920	3020
37	2500	2600	2700	2790	2890	2990
38	2470	2570	2670	2760	2860	2960
39	2440	2540	2640	2740	2830	2930
40	2410	2510	2610	2710	2810	2900
41	2380	2480	2580	2680	2780	2880
42	2360	2450	2550	2650	2750	2850
43	2330	2420	2520	2620	2720	2820
44	2300	2400	2490	2590	2690	2790
45	2270	2370	2470	2560	2660	2760
46	2240	2340	2440	2540	2630	2730
47	2210	2310	2410	2510	2600	2700
48	2180	2280	2380	2480	2580	2670
49	2150	2250	2350	2450	2550	2650
50	2130	2220	2320	2420	2520	2620

Source: Bair, William M. 1965. Weight-scaling pine sawlogs in Texas. Texas Forest Serv. Bull. 52.

TABLE 62.—Weight per log for southern pine

Average diameter of logs on load	Average length of load in feet: 12	14	16
In.	Pounds		
7.5	261-300	313-358	365-418
8.0	301-340	359-405	418-474
8.5	341-380	406-455	475-531
9.0	381-450	456-540	532-630
10.0	451-550	541-660	631-770
11.0	551-658	661-790	771-920
12.0	659-778	791 933	921-1088
13.0	779-905	934-1085	1089-1268
14.0	906-1040	1089-1253	1269-1460
15.0	1041-1185	1254-1430	1461-1665
16.0	1186-1335	1431-1610	1666-1875
17.0	1336-1565	1611-1800	1876-2085

Source: Barton, W. J. 1966. Weight versus volume for use in measuring forest products. *In*: T. D. Keister (Ed.) Measuring the southern forest. Louisiana State Univ. Press, Baton Rouge.

factors, Table 62, and obtain the number of board feet per 1,000 pounds for this specific average diameter and length.

7. Multiply the number of 1,000 pounds on the load by the conversion factor and obtain the board foot volume for the load of logs.

These table values are representative rather than actual in any one case. If found to be applicable in a local situation, however, they may be useful instruments in initiating sawtimber weight scales.

A visual example of weight-length-diameter relationships can be seen in Figure 4 (Davis, 1963). Davis constructed the nomograph for pulpwood and small sawtimber logs from data provided by Siegel and Row (1960), and his method of presentation enables rapid and accurate solutions of an original weight equation.

Weight Inventory as a Management Tool

Because of the interest generated in establishing land inventories by weight of timber growing stock, several papers have related weight to standing timber. Siegel and Row (1960) related approximate sawlog weights in loblolly

TABLE 63.—Board foot conversion factors, Doyle scale, per 1,000 pounds of logs for each diameter and log length class

Average diameter of logs on load	Average length of load in feet		
	12	14	16
In.		Pounds	
7.5	--	44.4	51.8
8.0	--	50.7	52.1
8.5	--	53.6	54.5
9.0	50.0	52.4	55.4
10.0	53.5	57.5	60.6
11.0	58.0	63.8	66.5
12.0	64.0	70.0	72.1
13.0	69.5	76.4	78.0
14.0	75.0	82.5	83.8
15.0	80.2	88.8	89.5
16.0	85.6	95.0	95.3
17.0	--	102.0	99.8
18.0	--	107.5	107.0

Source: Barton, W. J. 1966. Weight versus volume for use in measuring forest products. *In*: T. D. Keister (Ed.) Measuring the southern forest. Louisiana State Univ. Press, Baton Rouge.

TABLE 64.—Factors for estimating board feet in loads of different average log weights

Average log weight	Average scaling diameter	Doyle rule	Scribner rule	International rule
Lbs.	In.		Board feet per ton	
440	8	78 (95)[1]	141	180
540	9	100 (109)	158	190
660	10	121 (126)	171	200
780	11	138 (142)	182	208
920	12	154 (158)	191	215

[1] Of the two sets of figures under the Doyle rule, those in parentheses are intended for use when logs less than 8 inches in diameter are scaled as their length in feet.

Source: Siegel, W. C., and Clark Row. 1960. Selling sawlogs by the ton. Forest Farmer 19(13):8-9.

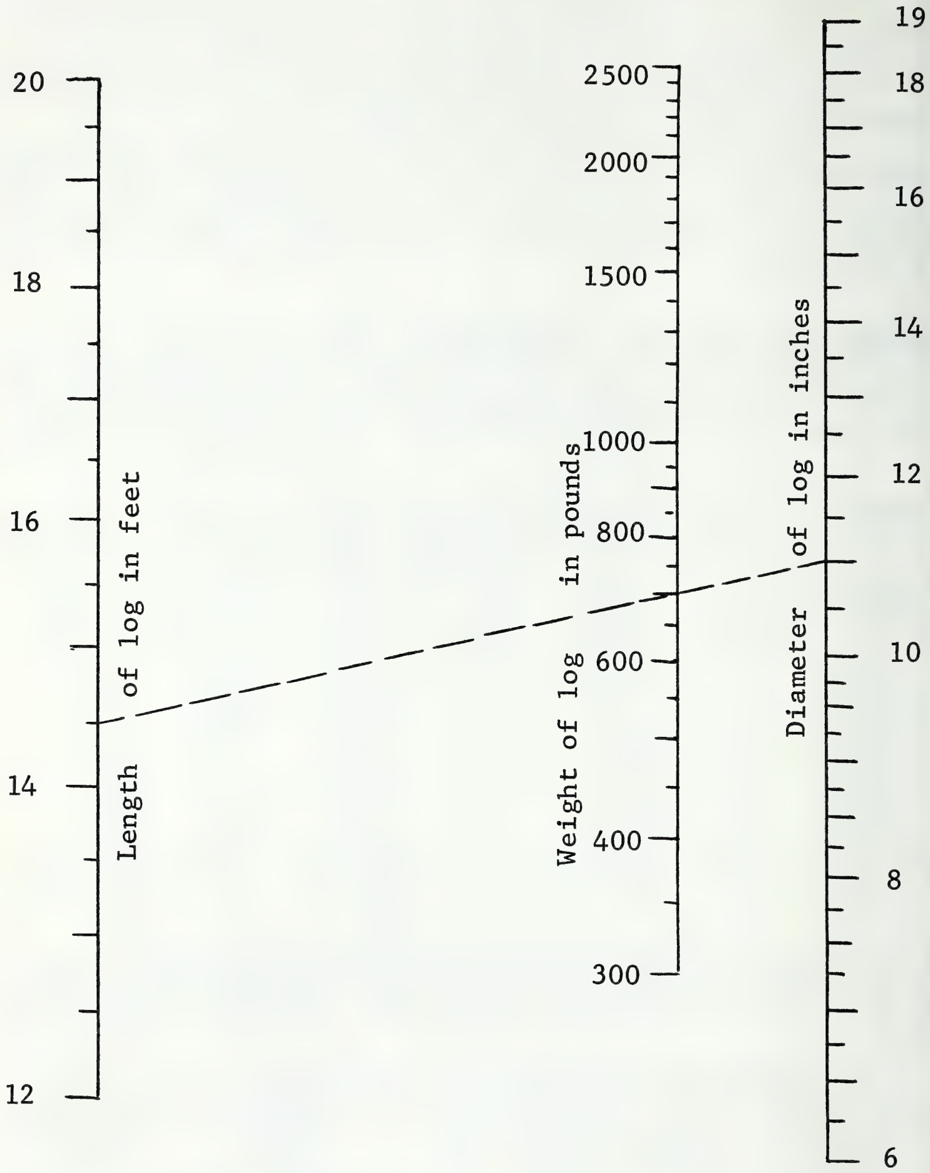

FIGURE 4.—Nomograph for weights of pulpwood logs. (Adapted from Davis, D. S. 1963. Nomograph for weights of pulpwood logs. Paper Industry 45:662.)

and shortleaf pines by form class and number of logs per tree for different Dbh classes (Table 65). Similar studies of pulpwood weights for trees have been conducted by McGee (1959) and Romancier (1961) for loblolly and slash pine stands (Table 66). Both studies showed an increase in green weight with increases in stem height. Refer to these bulletins for information on how weight inventories were established on southern pine lands.

Weight is a function of density, solid volume, bark weight, and moisture content, but the absolute values attached to these relationships are functions of other factors such as bolt or log length, diameter, species, and inherent growth characteristics. Even with a knowledge of the amount of cell wall substance per unit of volume, weight measure is confused by the inverse relationship between specific gravity and moisture content. Figure 5 shows an average relationship between moisture content and oven-dry wood density for pulpwood bolts. Thus, if the variations among growth characteristics could be eliminated, wood weight could be predicted for a given change in any one of the contributing factors.

TABLE 65.—Approximate total green weight for sawlogs in loblolly and shortleaf pine trees

.Dbh	Merchantable length by number of logs			
	1	2	3	4
In.	Tons			
10				
12	0.16	0.35	0.48	--
14	.21	.48	.69	--
16	.28	.65	.93	1.15
18	--	.83	1.19	1.54
20	--	1.06	1.51	1.95
	--	1.30	1.78	2.38

Source: Siegel, W. C., and Clark Row. 1960. Selling sawlogs by the ton. Forest Farmer 19(13):8-9.

TABLE 66.—Merchantable weight, including bark, for slash pine planted on old fields in the Carolina Sandhills

Dbh	Total tree height in feet											
	20	25	30	35	40	45	50	55	60	65	70	75
In.	Pounds											
	Top diameter, 4.0 inches outside bark											
5	---	32	45	64	82	100	119	137	155			
6	42	67	94	120	146	173	199	226	252	279		
7		115	151	187	223	259	295	331	367	403	439	
8			217	264	311	358	405	452	499	546	593	640
9				351	411	470	530	589	649	708	768	827
10					522	596	669	743	816	890	963	1037
11					646	734	824	913	1001	1090	1179	1268
12					781	887	992	1098	1204	1310	1416	1521
	Top diameter, 3.0 inches outside bark											
5	49	67	84	102	120	138	156	174	192			
6	81	106	131	158	183	209	235	261	287	313		
7		153	188	223	258	293	328	364	399	434	469	
8			252	298	344	390	436	482	528	574	620	666
9				384	443	502	560	619	678	737	795	854
10					552	624	696	767	839	911	983	1054
11					672	758	845	932	1019	1106	1193	1279
12					804	907	1012	1116	1220	1325	1429	1533
	Top diameter, 2.0 inches outside bark											
5	71	89	107	124	142	160	177	195	213			
6	102	128	154	179	205	231	256	281	307	333		
7		174	209	244	279	314	349	384	418	453	488	
8			273	319	364	410	455	501	547	592	638	683
9				403	461	519	576	634	692	749	807	865
10					569	640	712	783	854	925	997	1068
11					689	775	861	947	1034	1120	1206	1292
12					820	922	1025	1125	1230	1332	1435	1537

Source: McGee, C. E. 1959. Weight of merchantable wood with bark from planted slash pine in the Carolina sandhills. U.S. Forest Serv., Southeast. Forest Exp. Sta., Res. Note 128.

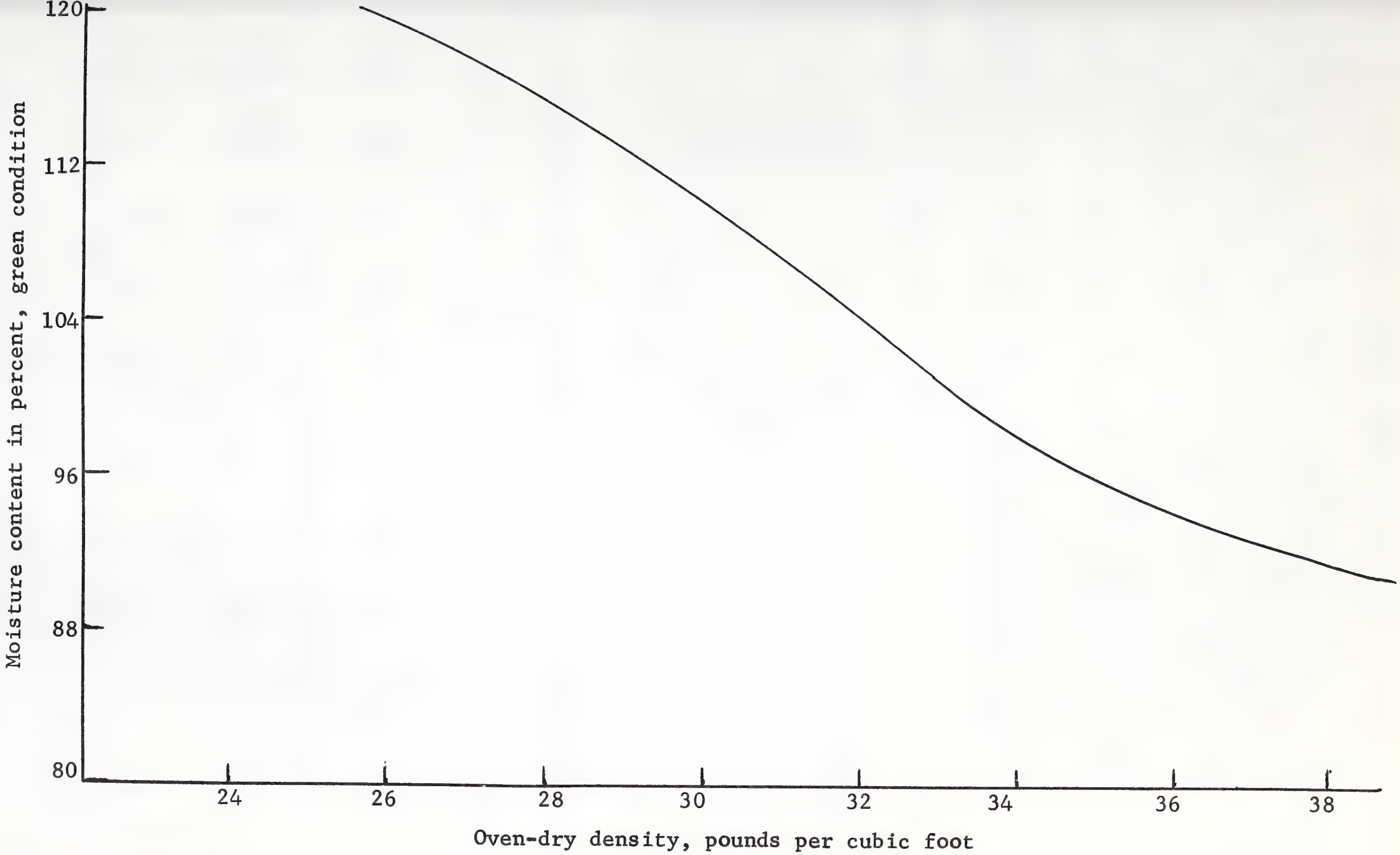

FIGURE 5.—Relationship between oven-dry density and moisture content in southern pine pulpwood bolts.

Veneer and Plywood

During the research period, considerable information was accumulated relating to all phases of plywood manufacture. The most practical and frequently used information, in the form of conversion tables for production yields, was determined from data collected during operational plant studies. Hopefully, these conversions will be of significant value to plant managers, production supervisors, and other management personnel in the growing number of southern pine plywood plants.

Residue from the manufacture of one MBF veneer logs, Doyle scale, results

TABLE 67.—Factors for converting surface measure to 3/8 footage and 3/8 footage to surface measure, by panel thickness[1]

Panel thickness	Surface measure to 3/8	3/8 Footage to surface measure
Inches		
5/16 or 1/4 sanded	.8333	1.2000
3/8	1.0000	1.0000
7/16 or 3/8 sanded	1.1667	.8569
1/2	1.3333	.7500
9/16 or 1/2 sanded	1.5000	.6667
5/8	1.6667	.5999
11/16 or 5/8 sanded	1.8333	.5456
3/4	2.0000	.5000
13/16 or 3/4 sanded	2.1667	.4615

[1] Multiply surface measure or 3/8 footage by the correct converting factor to obtain the corresponding value for any panel thickness.

TABLE 68.—Yield in lineal feet of veneer, rotary cut, from various size blocks[1]

Core dia.	Block length	Block diameter in inches								
		8	9	10	11	12	14	16	18	20
In.	In.	Feet								
				1/10 in. thick veneer						
5	102	25.2	36.3	48.7	62.4	77.3	111.2	150.1	194.5	244.0
4	102	31.2	42.2	54.8	68.4	83.3	117.2	156.1	200.4	249.9
3	102	35.8	47.6	59.2	73.0	87.9	121.8	160.7	205.1	254.4
				1/8 in. thick veneer						
5	102	20.4	29.3	39.2	50.1	62.4	89.8	121.2	157.0	196.9
4	102	25.1	34.1	44.1	55.2	67.2	94.6	126.0	161.8	201.7
3	102	28.8	37.4	47.8	58.9	71.0	98.3	129.8	165.5	205.4
				3/16 in. thick veneer						
5	102	13.5	19.4	26.1	33.4	41.4	59.6	80.5	104.2	130.4
4	102	16.7	22.6	29.4	36.6	44.6	62.8	83.7	107.4	133.9
3	102	19.2	25.5	31.8	39.1	47.1	65.3	86.6	109.9	136.4

[1] Lineal footage figures on a volumetric basis, assuming each bolt to be a perfect cylinder at the time of measurement.

$$\text{Lineal footage} = \frac{\text{Block volume} - \text{Core volume}}{\text{Volume of 1 foot of (1/10, 1/8, 3/16 in.) veneer}}$$

Source: Borden Chemical Company. 1966. Conversion tables for the southern pine plywood industry. Interim Report 11.

in 1.25 tons of veneer clippings suitable for potential pulp chips (Applefield, 1956).

The most common conversion necessary in plywood manufacture is obtaining the square feet of surface measure for panels of a particular thickness and then converting to obtain the ⅜ footage. Net surface measure in square feet for 48- × 96-inch panels is obtained by multiplying the number of panels times 32. Multiply by the factors in Table 67 to obtain the ⅜ footage when the surface measure is known, or vice versa.

When setting up production schedules, management personnel find it necessary to be able to predict the veneer yield from a given quantity of blocks. Variables which affect the yield are block diameter, thickness of veneer to be cut, minimum core block diameter, and log grade. Some of these variables are taken into account in Table 68. It should be noted that veneer grade yield can be accurately determined only by processing a large number of blocks from a single timber source.

Width Distribution of Veneer

The quality of veneer that can be obtained from a certain log diameter often determines the marginal scaling diameter for an operation. Information to use in determining the optimum log size is provided in Table 69, which gives veneer yield as a percentage distribution of widths that may be recovered from logs of different diameters under normal conditions of operation. Fishtail[1] volume is becoming increasingly important, since almost all plywood mills are now chipping green waste.

Stacked Volume of Veneer

Stacks of dry veneer are often accumulated during peak periods of manufacture. Table 70 provides conversion factors that have been used in production control to determine the actual quantity of 1/8- and 1/10-inch veneer in a stack.

Data from one company report, based on information gathered from the processing of 150 loblolly and shortleaf pine logs, showed the following veneer

---

[1] Fishtail volume is the chippable waste that is removed in the rounding-up process.

TABLE 69.—Veneer yields by distribution of widths[1]

Scaling diameter	Veneer width			
	54 in.	27 in.	Randoms	Fishtails[2]
In.	Percent			
8	0	39	35	26
9	0	36	51	13
10	5	56	25	14
11	53	19	18	10
12	42	37	15	6
13	59	13	23	5
14	50	11	28	11

[1] Reported by one southern pine plywood manufacturer. Values given are expressed as a percent of the total veneer yield for each diameter class and are representative of values that may be expected from normal operation.

[2] Fishtails are the veneer residues that are lost in rounding-up the log.

recoveries for southern pine. Veneer was ⅛ inch thick and was cut from 8-foot logs having an average specific gravity of 0.481 (range 0.436 to 0.567, based on oven-dry volume and oven-dry weight).

	Percent
Veneer from lathe:	
Yield	87.1
Core and spur loss	12.9
Veneer from green clipper:	
Yield	57.6
Clipper loss	42.4
Veneer width distribution after clipper:	
54-inch	29.4
27-inch	22.7
Random widths	47.9

Logs in the study qualified under the following specifications: core diameter was 5½ inches; average block diameter was 14.76 inches; average rate of growth was 9 rings per inch outside the 5½-inch-diameter core; average moisture content of the sapwood was 128 percent and that of the heartwood was 45 percent. Logs were mostly grade 2 and 3 by U.S. Forest Service grades for southern pine logs.

TABLE 70.—Converting factors used to determine the square footage of stacked veneer on a ⅜-inch basis[1] [2]

	Widths			
Thickness	54 in.	27 in.	Randoms	Fishtails
		Green Veneer		
1/10 in.	56.9	56.9	54.9	27.4
1/8 in.	58.5	58.5	56.4	28.2
		Dry Veneer		
All sizes	55.9		44.1	

[1] Data were obtained from one southern pine plywood plant and have been used in production control.

[2] Multiply conversion factor by height of veneer stack in inches to obtain square feet of veneer on a ⅜-inch basis. Factors allow for a 20 percent loss due to green clipping, drying, and compression of dry, stacked veneer.

TABLE 71.—Veneer yield, ⅜-inch basis, by dbh class for Doyle and International log rules[1]

Dbh class	Plywood yield per board foot[2]		Avg. plywood per bolt[2]	Plywood yield per board foot[3]	
	Doyle	International		Doyle	International
In.	Square feet				
10	4.49	2.43	37.8	4.72	1.97
12	4.46	2.60	51.9	4.83	2.29
14	3.96	2.56	76.3	4.42	2.49
16	3.51	2.43	93.8	3.74	2.38
18	3.50	2.60	133.3	3.89	2.67

[1] Obtained from one southern pine plywood firm. Constant core diameter was 4.25 inches. A 10 percent lay-up loss was deducted from table values.

[2] All bolts were scaled as 8-foot logs.

[3] All 17-foot logs were scaled as regular 16-foot logs and remaining bolts were scaled as 8-foot logs.

Plywood Recovery

Veneer yields, on a ⅜-inch basis for plywood recovery, were provided by industry sources by Dbh classes, by pole classes, and by scaling diameter, as shown in Tables 71, 72, and 73 respectively. One published study indicated that conversion ratios of at least 2.5 square feet of veneer per board foot of log scale are readily attainable (Guttenberg, 1967).

Core Utilization

Veneer cores may be chipped, treated, and sold for fence posts, or sawn into two studs. Regardless of the utilization process, Table 9 shows the number of veneer cores by diameter that may be stacked in an area occupied by a standard cord.

For practical purposes, the weight per cubic foot of cores, regardless of bolt characteristics, is 45.76 pounds (Guttenberg, 1967).

TABLE 72.—Veneer yield, ⅜-inch basis, expressed as square feet of plywood per board foot, Doyle log rule, by pole class[1] [2]

Pole length	Pole class 1	2	3	4	5	Avg.
Ft.	Sq. Ft. per Bd. Ft.					
40		3.25	3.21	2.91	3.31	3.15
50	3.12	3.48	3.24	3.22	3.21	3.29
60	2.76	2.93	2.87	2.86	3.23	2.88
70	2.75	3.09	2.91	4.06		3.01
80	2.90	2.70	2.93			3.16
90	2.64	2.85				2.78
Avg.	2.77	3.00	3.00	3.23	3.24	2.94

[1] Table values are based on log scales of 16-foot logs plus remaining 8-foot logs as reported by one southern pine plywood firm.

[2] Constant core diameter of 4.5 inches. Table values are reduced 10 percent for lay-up losses.

TABLE 73.—Product yields of grade 1 and 2 bolts per MBF Doyle rule[1]

Scaling diameter	Veneer ⅜-in. basis	Pulp chips	Veneer cores
In.	M Sq. Ft.	M Lbs.	M Lbs.
10	2.61	5.26	3.03
12	2.75	3.48	1.70
14	2.74	2.62	1.09
16	2.64	2.12	0.76
18	2.59	1.82	.56
20	2.54	1.62	.43
22	2.46	1.46	.34
24	2.43	1.36	.27

[1] A core diameter of 5.2 inches was assumed as further peeling would yield only small amounts of usable veneer and a 5.2-inch core could be split into two studs.

Source: Guttenberg, Sam. 1967. Veneer yields from southern pine bolts. Forest Prod. Jour. 17 (12) :30-32.

Plywood Yields

Table 74 gives the yield of ⅜-inch plywood from block diameters of 8 to 20 inches. A 40 percent reduction is included in the table to account for the loss of material during manufacture. This loss is broken down in the following manner: 20 percent green clipping loss, 15 percent loss in drying, dry clipping, and spreading the adhesive, and 5 percent loss in sizing of panels.

Table 75 gives factors for converting board feet to ⅜-inch plywood. Factors are given for the four scales used to describe the board foot measure: perfect cylinder, International scale, Scribner Decimal C rule, and the Doyle rule.

TABLE 74.—Veneer yield on ⅜-inch basis for various block sizes, and estimated average number of blocks required to produce one thousand square feet of ⅜-inch plywood[1]

Scaling diameter	Core diameter in inches		
	3	4	5
In.	Veneer yield in square feet		
8	46.1	40.1	32.6
10	76.5	70.6	62.7
12	113.6	107.5	99.8
14	157.3	151.4	143.7
16	207.7	201.6	193.9
18	264.8	258.9	251.2
20	328.6	322.7	315.0
	Average number of blocks		
8	22	25	31
10	13	14	16
12	9	9	10
14	6	7	7
16	5	5	5
18	4	4	4
20	3	3	3

[1] Table values are based on calculations and estimates. A 40 percent reduction is included in the table for the following: 20 percent green clip loss; 15 percent dryer, dry clip, and spreader waste; and 5 percent side trim of panels.

Source: Borden Chemical Company. 1966. Conversion tables for the southern pine plywood industry. Interim Report 11.

TABLE 75.—Factors for converting board feet to square feet of ⅜-inch plywood based on various log rules[1]

Scaling diameter	Core diameter in inches											
	Perfect cylinder			International ¼-inch			Scribner Decimal C			....Doyle......		
In.												
8	1.4	1.2	1.0	3.1	2.7	2.2	4.6	4.0	3.3	5.8	5.0	4.1
10	1.4	1.3	1.2	2.6	2.4	2.1	2.6	2.4	2.1	4.2	3.9	3.5
12	1.5	1.4	1.3	2.5	2.4	2.2	2.8	2.7	2.5	3.6	3.4	3.1
14	1.5	1.5	1.4	2.4	2.3	2.2	2.6	2.5	2.4	3.1	3.0	2.9
16	1.5	1.5	1.4	2.4	2.4	2.3	2.6	2.5	2.4	2.9	2.8	2.7
18	1.6	1.5	1.4	2.4	2.4	2.3	2.3	2.3	2.2	2.6	2.5	2.5
20	1.6	1.5	1.5	2.4	2.4	2.3	2.3	2.3	2.2	2.6	2.5	2.5

[1] Table values are based on calculations and estimates, assuming an 8-foot block length. A 40 percent reduction is included in the table for the following losses: 20 percent, green clip; 15 percent, dryer, dry clip, and spreader waste; and 5 percent side trim of panels.

Source: Borden Chemical Company. 1966. Conversion tables for the southern pine plywood industry. Interim Report 11.

Values are given for block diameters of 8 to 20 inches and for peeling to 3 inches, 4 inches, and 5 inches. Loss during manufacture is included in Table 75 in the same manner as that used for Table 74.

The following is an example of the procedure in using Table 76: By the Doyle rule, an 8-inch-diameter log measuring 8 feet in length would scale 8 board feet; multiplying this figure by the 5.8 factor in Table 75, it is found that an 8-inch-diameter block will yield 46.4 square feet of ⅜-inch plywood. This figure compares very closely with that given in Table 74 for an 8-inch-diameter log.

Calculation of ⅜ Production Efficiency

Use of factors in Table 76 will allow an estimate of ⅜ recovery efficiency as compared to the potential ⅜ production for any manufacturing situation. For any period of production obtain the number of logs used, the weighted average log diameter, and the gross ⅜ footage of veneer from the green clipper. To determine the potential production, use tabular factors to obtain the ⅜ footage per block for the average diameter. Subtract from this figure the ⅜ footage in core material for the appropriate average core diameter, and multiply the remainder by the number of logs used. This figure is the potential ⅜ footage for that period. This figure may be divided into the gross ⅜ footage obtained from the green clipper to obtain a percentage estimate of recovery efficiency. Potential production efficiency may be obtained for both 4- and 8-foot logs.

TABLE 76.—Factors for determining potential ⅜ footage under production conditions

Average diameter	⅜ Contents of blocks and cores			
	4-Foot logs[1]		8-Foot logs[2]	
	Block	Cores	Block	Cores
Inches	⅜ footage			
4	12	11	27	22
5	19	17	40	35
6	27	25	57	50
7	36	35	76	69
8	47	45	98	91
9	59	56	123	110
10	73	69	150	140
11	87	85	181	170
12	104	100	214	200
13	122	115	250	235
14	141	135	289	275
15	161	155	330	315
16	183	180	375	355
17	206	200	422	400
18	231	225	472	455
19	257	250	525	505
20	285	280	580	560
21	314	310	639	615
22	344	340	699	675
23	376	370	764	740
24	409	400	830	805

[1] Formula for ⅜ footage is: $V = .262\ (\text{Dia} + .1875)^2\ (2.667)$
[2] Formula for ⅜ footage is: $V = .524\ (\text{Dia} + .375)^2\ (2.667)$

Lathe Capacity

Guttenberg (1967) determined the processing time for bolts by diameter class. The time for each bolt was the interval between drops of cores from the chucks. Hourly lathe capacity is estimated in Table 77 and includes reductions for unavoidable delays to clean chucks or to touch up knives.

TABLE 77.—Hourly lathe capacity[1]

Scaling diameter	Capacity	Scaling diameter	Capacity
Inches	MBF	Inches	MBF
8	1.62	18	9.21
10	3.13	20	10.40
12	4.77	22	11.45
14	6.37	24	12.37
16	7.87		

[1] Constant core diameter of 5.5 inches.

Source: Guttenberg, Sam. 1967. Veneer yields from southern pine bolts. Forest Prod. Jour. 17(12):30-32.

Pulp Utilization

One standard cord of southern pine pulpwood, as determined by a pulp manufacturer, may be broken down into the following percentage component parts during processing.[2]

Utilization process	Volume per cord
	Pct.
Bark	11.0
Fiber loss	
Debarking	2.0
Chips	1.0
Cooking rejects	7.0
Lignin, hemicelluloses	40.0
Finished sulphate pulp	
Unbleached	39.0
	100.0

Pulp yields vary with the process being used, with pulp grades among mills, with species, and with other factors that are inherent to the pulpwood itself. Average loss in pulping due to bleaching is 6 percent by volume. The following yields are average figures for the entire southern pulpwood industry and should not be considered as actual yield data.[3]

One ton unbleached kraft	requires 1.76 tons oven-dry chips
	requires 1.63 cords pulpwood
One ton unbleached kraft pulp	requires 1.89 tons oven-dry chips
	requires 1.72 cords pulpwood
One ton bleached kraft pulp	requires 2.04 tons oven-dry chips
	requires 1.85 cords pulpwood

One ton of air-dry pulp weighs 1,800 pounds in the oven-dry condition.

---

[2] Figures are a yearly average from one southern pine pulp and paper manufacturer. The major species is loblolly pine.

[3] All pulp yields are expressed in the air-dry condition at 6 percent moisture content.

One pulp manufacturer expressed pulp yields as a percent of the oven-dry weight of pulpwood substance:

Product	Region	
	Mid-South	Southeast
	Pct.	Pct.
Bleached kraft pulp	41	45
Unbleached kraft pulp	43	46
Unbleached kraft	48	49
Linerboard base stock	52	54

The 1966 yearly average for crude tall oil recovery among many southern pulp and paper mills was 55.1 pounds of tall oil per cord of pine pulpwood consumed. Extreme geographical variation existed among reporting mills.

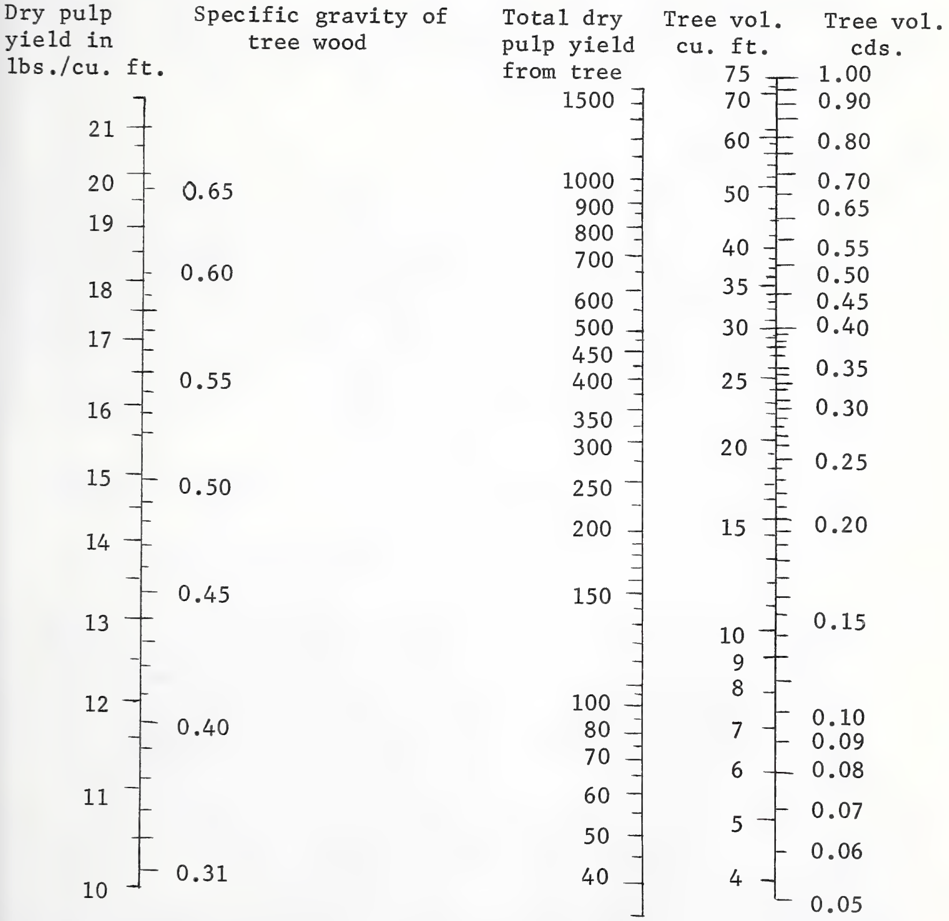

FIGURE 6.—Alignment chart for determining the dry pulp yield of slash pine, when the wood volume and the specific gravity are known. (Adapted from Perry, T. O., and Chi Wu Wang. 1958. Variation in the specific gravity of slash pine wood and its genetic and silvicultural implications. Tappi 41:178-180.)

Poles and Piling

Linear measure is used for such items as poles, piling, fence posts, and mining timbers. Length and strength are more important for these products than is actual volume alone.

Poles and piling are harvested, graded, and marketed on a piece-basis. Piece-products are classed, first by species and secondly by dimension, into definite grades. Specifications for each class and grade of product set forth the dimensions which will eventually determine the value of the finished product. The specifications and dimensions for southern pine poles that are to be given a preservative treatment, as set forth by the American Standards Association in 1963, immediately follow this discussion. Acceptable dimensions are given in Table 78 for classes of poles by size, weight, and volume. Minimum acceptable diameters are shown in a convenient and accurate form in Table 79.

As a general rule, most board foot volume tables for poles are inconsistent with actual pole measurements. Volume tables tend to underestimate pole volume, probably because poles taper more rapidly to a larger butt than to a minimum-sized butt.

Pole Volume Table

When pole production is integrated with sawlog and pulpwood production, it may become necessary to obtain an estimate of the board foot content in poles. Figure 7 gives volume of southern pine poles by lengths and classes based on the International rule. Table 80 shows the conversion into board feet by the Scribner log rule. Before using this table, however, a representative sample of poles should be scaled to determine if the values are locally applicable. When the figures are inconsistent with local volumes, the method outlined by Hawes (U.S. Forest Service, 1959) shows how a local pole volume table can be constructed:

1. Obtain rough-pole circumference at mid-point of class measurements.
2. Average dbh is found from the formula:

$$\frac{\text{rough pole circumferences at mid-point of class } (\times)\ 1.136}{3.1416}$$

3. Average dbh (×) form class 89 = dib at 16-foot height.
4. Dib above 16-foot height is obtained by using taper values in Table 19. Logs shorter than 16 feet have taper proportional to their length.
5. Using Table 24, Scribner volume is applied to diameter classes. For poles less than 16 feet long the volume is proportional to the pole's length.

The same procedure can be followed to construct similar tables based on the International or Doyle volumes, using appropriate tables from the board foot volume section.

Strength requirements for pilings are more exacting than those for poles. Because of the tremendous shock they undergo in the driving process, piles must be stronger and completely sound. Table 81 summarizes the American Society for Testing and Materials specifications for circumferences and diameters of southern pine piling.

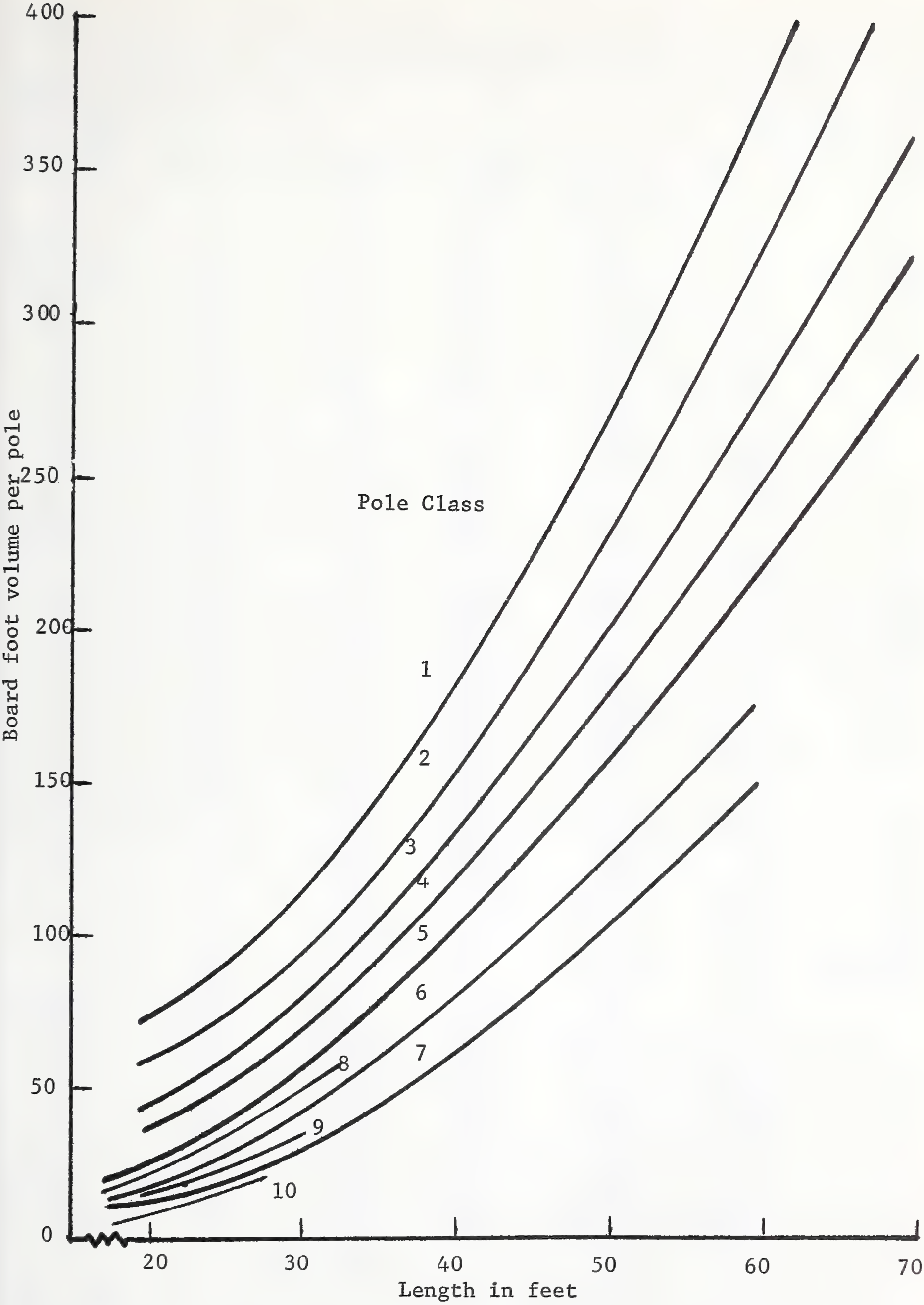

FIGURE 7.—Board foot volume of southern pine poles based on International ¼-inch log rule, by length and pole class. (Adapted from Williston, H. L. 1957. Pole grower's guide. U.S. Forest Serv., South. Forest Exp. Sta., Occ. Paper 153.)

TABLE 78.—American Standards Association dimensions of southern pine poles by size, weight, and volume

Class and minimum circumference and equivalent dia. of top of pole	Length	Weight[1]	Volume	Minimum circumference and equivalent diameter at 6 feet from butt	
				Circumference	Diameter
In.	Ft.	Lbs.	Cu. Ft.	In.	In.
Class 1	20	710	12.91	31.0	9.78
27 In. Circum.	25	990	18.00	33.5	10.66
8.59 In. Diam.	30	1279	23.25	36.5	11.62
	35	1568	28.50	39.0	12.41
	40	1884	34.25	41.0	13.05
	45	2223	40.41	43.0	13.69
	50	2585	47.00	45.0	14.32
	55	2993	54.42	46.5	14.80
	60	3451	62.75	48.0	15.28
	65	4015	73.00	49.5	15.76
	70	4620	84.00	51.0	16.23
	75	5198	94.50	52.5	16.71
	80	5867	106.67	54.0	17.19
	85	6600	120.00	55.0	17.51
	90	7462	135.67	56.0	17.82
Class 2	20	564	10.25	29.0	9.24
25 In. Circum.	25	811	14.75	31.5	10.03
7.96 In. Diam.	30	1082	19.67	34.0	10.82
	35	1343	24.42	36.5	11.62
	40	1623	29.50	38.5	12.25
	45	1911	34.75	40.5	12.89
	50	2214	40.25	42.0	13.36
	55	2567	46.67	43.5	13.85
	60	2943	53.50	45.0	14.32
	65	3341	60.75	46.5	14.80
	70	3781	68.75	48.0	15.28
	75	4235	77.00	49.0	15.60
	80	4739	86.17	50.5	16.07
	85	5266	95.75	51.5	16.39
	90	5871	106.75	53.0	16.87
Class 3	20	468	8.50	27.0	8.59
23 In. Circum.	25	674	12.25	29.5	9.39
7.32 In. Diam.	30	921	16.75	32.0	10.18
	35	1155	21.00	34.0	10.82
	40	1403	25.50	36.0	11.46
	45	1664	30.25	37.5	11.94
	50	1925	25.00	39.0	12.41
	55	2200	40.00	40.5	12.89
	60	2512	45.67	42.0	13.36
	65	2814	51.17	43.5	13.85
	70	3144	57.17	45.0	14.32
	75	3506	63.75	46.0	14.67
	80	3887	70.67	47.0	14.96
	85	4299	78.17	48.0	15.28
	90	4730	86.00	49.0	15.60

(Continued)

TABLE 78.—(Continued)

Class and minimum circumference and equivalent dia. of top of pole	Length	Weight[1]	Volume	Minimum circumference and equivalent diameter at 6 feet from butt	
				Circumference	Diameter
In.	Ft.	Lbs.	Cu. Ft.	In.	In.
Class 4	20	394	7.17	25.0	7.96
21 In. Circum.	25	573	10.42	27.5	8.75
6.68 In. Diam.	30	784	14.25	29.5	9.39
	35	1004	18.25	31.5	10.03
	40	1219	22.17	33.5	10.66
	45	1444	26.25	35.0	11.14
	50	1687	30.67	36.5	11.62
	55	1934	35.17	38.0	12.10
	60	2186	39.75	39.0	12.41
	65	2457	44.67	40.5	12.89
	70	2732	49.67	41.5	13.21
	75	3021	54.92	43.0	13.69
	80	3314	60.25	44.0	14.00
Class 5	20	330	6.00	23.0	7.32
19 In. Circum.	25	491	8.92	25.5	8.12
6.05 In. Diam.	30	660	12.00	27.5	8.75
	35	862	15.67	29.0	9.23
	40	1059	19.25	31.0	9.87
	45	1274	23.17	32.5	10.34
	50	1494	27.17	34.0	10.82
	55	1719	31.25	35.0	11.14
	60	1953	35.50	36.0	11.46
	65	2237	40.67	37.5	11.94
	70	2498	45.25	38.5	12.25
Class 6	20	284	5.17	21.0	6.67
17 In. Circum.	25	422	7.67	23.0	7.32
5.41 In. Diam.	30	550	10.00	25.0	7.96
	35	743	13.50	27.0	8.59
	40	921	16.75	28.5	9.07
	45	1114	20.25	30.0	9.55
	50	1329	24.17	31.5	10.03
	55	1563	28.42	32.5	10.34
	60	1801	32.75	33.5	10.66
Class 7	20	234	4.25	19.5	6.21
15 In. Circum.	25	344	6.25	21.5	6.84
4.77 In. Diam.	30	454	8.25	23.5	7.48
	35	646	11.75	25.0	7.96
	40	807	14.67	26.5	8.43
	45	976	17.75	28.0	8.91
	50	1169	21.25	29.0	9.23
Class 9	20	202	3.67	17.5	5.57
15 In. Diam.	25	289	5.25	19.5	6.21
4.77 In. Diam.	30	371	6.25	20.5	6.52
Class 10	20	161	2.92	14.0	4.46
12 In. Diam.	25	234	4.25	15.0	4.77
3.82 In. Diam.					

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[1] Weight based on 55 lbs. per cubic foot for longleaf pine (U.S. Forest Products Labatory weight). Other species: Loblolly pine, 53 lbs., shortleaf pine, 52 lbs.

Source: American Standards Association. 1963. American standard specifications and dimensions for wood poles.

TABLE 79.—Circumference dimensions for southern pine poles[1]

Pole class		1	2	3	4	5	6	7	9	10
Min. circumference at top in inches		27	25	23	21	19	17	15	15	12
Pole length	Groundline distance from butt[2]	Minimum circumference at 6 feet from butt								
Ft.	Ft.	Inches								
20	4	31.0	29.0	27.0	25.0	23.0	21.0	19.5	17.5	14.0
25	5	33.5	31.5	29.5	27.5	25.5	23.0	21.0	19.5	14.0
30	5.5	36.5	34.0	32.0	29.5	27.5	25.0	23.5	20.5	
35	6	39.0	36.5	34.0	31.5	39.0	27.0	25.0		
40	6	41.0	38.5	36.0	33.5	31.0	28.5	26.5		
45	6.5	43.0	40.5	37.5	35.0	32.5	30.0	28.0		
50	7	45.0	42.0	39.0	36.5	34.0	31.5	29.0		
55	7.5	46.5	43.5	40.5	38.0	35.0	32.5			
60	8	48.0	45.0	42.0	39.0	36.0	33.5			
65	8.5	49.5	46.5	43.5	40.5	37.5				
70	9	51.0	48.0	45.0	41.5	38.5				
75	9.5	52.5	49.0	46.0	43.0					
80	10	54.0	50.5	47.0	44.0					
85	10.5	55.0	51.5	48.0						
90	11	56.0	53.0	49.0						
95	11	57.0	54.0	50.0						
100	11	58.5	55.0	51.0						
105	12	59.5	56.0	52.0						
110	12	60.5	57.0	53.0						
115	12	61.5	58.0							
120	12	62.5	59.0							
125	12	63.5	59.5							

[1] Table values are based on fiber stress of 8,000 psi. Classes and lengths for which circumferences at 6 feet from the butt are listed inside brackets are the preferred standard sizes. Those shown outside brackets are included for engineering purposes only.

[2] Use figures in this column only when a definition of groundline is necessary in order to apply requirements relating to scars, straightness, etc.

Source: American Standards Association. 1963. American standard specifications and dimensions for wood poles.

TABLE 80.—Average board foot content of poles based on Scribner log rule and form class 80

Length	Pole class							
	1	2	3	4	5	6	7	9
Ft.	Board feet							
25			70	55	45	35	25	20
30	125	105	85	70	55	45	35	25
35	155	135	115	90	75			
40	205	175	150	130	100			
45	245	210	180	145	120			
50	280	240	205	170				
55	335	295	250					
60	385	325	280					
65	420	365						
70	495	425						
75	535							
80	570							

Source: Hawes, E. T. 1959. *In*: Volume tables, converting factors, and other information applicable to commercial timber in the South. 7th Ed., p.41-42. U.S. Forest Serv., Div. of State and Private Forestry, Atlanta.

TABLE 81.—Circumferences and diameters of southern pine piles

Length in feet	Class A						Class B						Class C					
	3 ft. from butt				At tip, min.		3 ft. from butt				At tip, min.		3 ft. from butt				At tip, min.	
	Min.		Max.				Min.		Max.				Min.		Max.			
	Circumference, In.	Diameter (approx.), In.	Circumference, In.	Diameter (approx.), In.	Circumference, In.	Diameter (approx.), In.	Circumference, In.	Diameter (approx.), In.	Circumference, In.	Diameter (approx.), In.	Circumference, In.	Diameter (approx.), In.	Circumference, In.	Diameter (approx.), In.	Circumference, In.	Diameter (approx.), In.	Circumference, In.	Diameter (approx.), In.
Under 40	44	14	57	18	28	9	38	12	63	20	25	8	38[1]	12[1]	63	20	25	8
40 to 50 incl.	44	14	57	18	28	9	38	12	63	20	22	7	38	12	63	20	19	6
55 to 70 incl.	44	14	57	18	25	8	41	13	63	20	22	7	38	12	63	20	19	6
75 to 90 incl.	44	14	63	20	22	7	41	13	63	20	19	6	38	12	63	20	19	6
Over 90	44	14	63	20	19	6	41	13	63	20	16	5	38	12	63	20	16	5

[1] In class C piles, a minimum circumference of 31 inches or diameter of 10 inches at least 3 feet from the butt may be specified for lengths of 20 feet and under.

Source: American Society for Testing and Materials. 1967. Part 16. ASTM Standard D 25-58.

A.S.A. Specifications for Poles, March 1963

Length—Poles less than fifty (50) feet in length shall not be over three (3) inches shorter or six (6) inches longer than their nominal length. Poles fifty (50) feet or over in length shall not be over six (6) inches shorter or twelve (12) inches longer than their nominal length.

Circumference—Poles shall be classified with respect to their circumference in accordance with the table entitled "Dimensions of A.S.A. Southern Pine Poles." The circumference at 6 feet from the butt of a pole shall be not more than 7 inches or 20 percent larger than the specified minimum, whichever is greater.

The top dimensional requirement shall apply at a point corresponding to the minimum length permitted for the pole.

Shape—Poles shall be free from short crooks. Poles may have sweep in two planes or sweep in two directions in one plane, provided that a straight line connecting the mid-point at the ground-line with the center of the top does not at any intermediate point pass through the external surface of the pole.

Where sweep is in one direction and one plane only, 90 percent of the inspection lot less than 55 feet in length shall not have sweep greater than 1 inch for each 10 feet of length. The remainder of the inspection lot (10 percent) may not have sweep greater than 1 inch in 6 feet of length.

For poles 55 feet and longer, 75 percent must meet the 1 inch in 10 feet requirement, and the remainder of the lot (25 percent) may have a deviation of 1 inch in 6 feet.

Material Requirements—All poles shall be cut from live southern yellow pine timber (*Pinus palustris, P. elliottii, P. taeda,* and *P. echinata*).

All poles shall be free from cross breaks, decay, dead knots and defective butts, dead streaks, holes, hollow butts or tops, and marine borer damage. All poles shall be free from nails, spikes, and other metal. Blue sap stain and hollow pith centers in the tops or butts and in knots are permitted in poles that are to be given full-length treatment.

Insect Damage—Insect damage consisting of holes 1/16 inch or less in diameter, or surface scoring or channeling is permitted.

Grain—Spiral grain is permitted as follows:

Length of pole	Maximum spiral grain permitted
35 feet and less	1 complete twist in any 10 feet
35 to 45 feet, inclusive	1 complete twist in any 16 feet
50 feet and longer	1 complete twist in any 20 feet

Shakes—Shakes in the butt surface are permitted, provided that they are not closer than 2 inches to the side surface of the pole. Such shakes shall not extend to the ground-line.

Shakes in the top surface are permitted in poles that are to be given full-length treatment, provided that the diameter of the shake is not greater than one-half the diameter of the top of the pole.

Splits and Checks—In the top: A split or a combination of two single checks having one or both portions located in a vertical plane within 30 degrees of the top bolt hole shall not extend downward along the pole more than 6 inches. All other combinations of checks or a split shall not extend downward along the pole more than 12 inches.

In the butt: A split or a combination of two single checks, as defined above, shall not extend upward along the pole for more than 2 feet.

Scars—No pole shall have a scar or turpentine face located within 2 feet of the ground-line. Turpentine scars need be trimmed only to the extent necessary for examination for evidence of fungus infection and insect damage.

Other sound scars are permitted elsewhere on the pole surface, provided they are smoothly trimmed and do not interfere with the cutting of any grain, and provided:

1. That the circumference at any point on trimmed surfaces located between the butt and 2 feet below the ground-line is not less than the minimum circumference specified at 6 feet from the butt for the class and length of pole; and
2. That the depth of the trimmed scar is not more than 2 inches, if the diameter is 10 inches or less, or ⅕ of the pole diameter at the location of the scar, if the diameter is more than 10 inches.

Knots and Holes—The diameter of any single knot and the sum of the knot diameters in any 1-foot section shall not exceed the following limits:

Pole length	Maximum sizes permitted: Diameter of any single knot		Maximum sizes permitted: Sum of diameters of all knots greater than 0.5 inch in any 1-ft. section
	Classes 1-3	Classes 4-10	Classes 1-10
Ft.	In.	In.	In.
45 or less			
Lower half of length	3	2	8*
Upper half of length	5	4	
50 or more			
Lower half of length	4	4	10*
Upper half of length	6	6	

*Both upper and lower halves

Manufacturing Requirements—All knots shall be trimmed close. Completely over-grown knots which do not rise more than 1 inch above the pole surface need not be trimmed.

All poles shall be neatly sawed at the butt along a plane which shall not be out of square with the axis of the pole by more than 2 inches per foot of butt diameter.

Beveling at the edge of the sawn butt surface not over one-twelfth of the diameter in width, or an equivalent area unsymmetrically located, is permitted.

Residue

Barking and chipping equipment make it possible for small- and medium-sized mills sawing pine logs to utilize wood residue profitably.

Slabs and Edgings

A study conducted at a southern pine sawmill showed that on the average, one thousand board feet of logs, Doyle scale, produced 1.73 tons of green, barked slabs and edgings; one ton of rough, green slabs and edgings produced an average of 1,350 pounds of chips, all of which were acceptable.

In a study of pine slabs and edgings in the South Carolina Piedmont, Todd and Anderson (1955) found that an average of 1,570 pounds of green wood (728 pounds oven-dry) was contained in a ton of rough, green slabs. They also found that one ton of rough, green edgings averaged 1,674 pounds of green wood (776 pounds of oven-dry).

The above converting factors from Todd and Anderson (1955) may be used for determining the weight of actual wood substance per ton of green, unbarked slabs and edgings from shortleaf pine. The figures may not apply to species with thinner or thicker bark, but the factors did not vary significantly with type of sawmills and varied only slightly with diameters of logs sawed. A maximum error of 3 percent may be expected.

Applefield (1956) determined the amount of solid wood content in a standard cord for each of the following products:

Product	Solid volume
	Cu. Ft.
Round-wood	76
Slabs	65
Edgings	40

Quantities of solid wood residue in Georgia varied inversely with log diameter at all types of sawmills, as shown in Figure 8 (Page and Saucier, 1958). The effect of log diameter, however, is inconsistent from mill to mill (Todd and Anderson, 1955)

Applefield (1960) determined southern pine residue yields in tons per MBF of lumber tally by log diameter and residue as shown in Table 82. Other things being equal, the proportion of total residue in slabs is low for the smallest logs, rises to a maximum at a diameter of about 10 inches, and then declines.

It is economically impractical to chip rough edgings, and the volume of bark in slabs increases progressively with log scaling diameter. Thus, from Table 83, the percentage of wood and bark contained in slabs, by volume and weight, may be used to determine the marginal slab size for barking and chipping for a given set of utilization conditions.

Todd (1955) computed the volume of bark-free wood in a cord of pine slabs (Table 84), and Lehman (1958) determined residue yield in tons per MBF log scale for the Doyle and International log rules (Table 85).

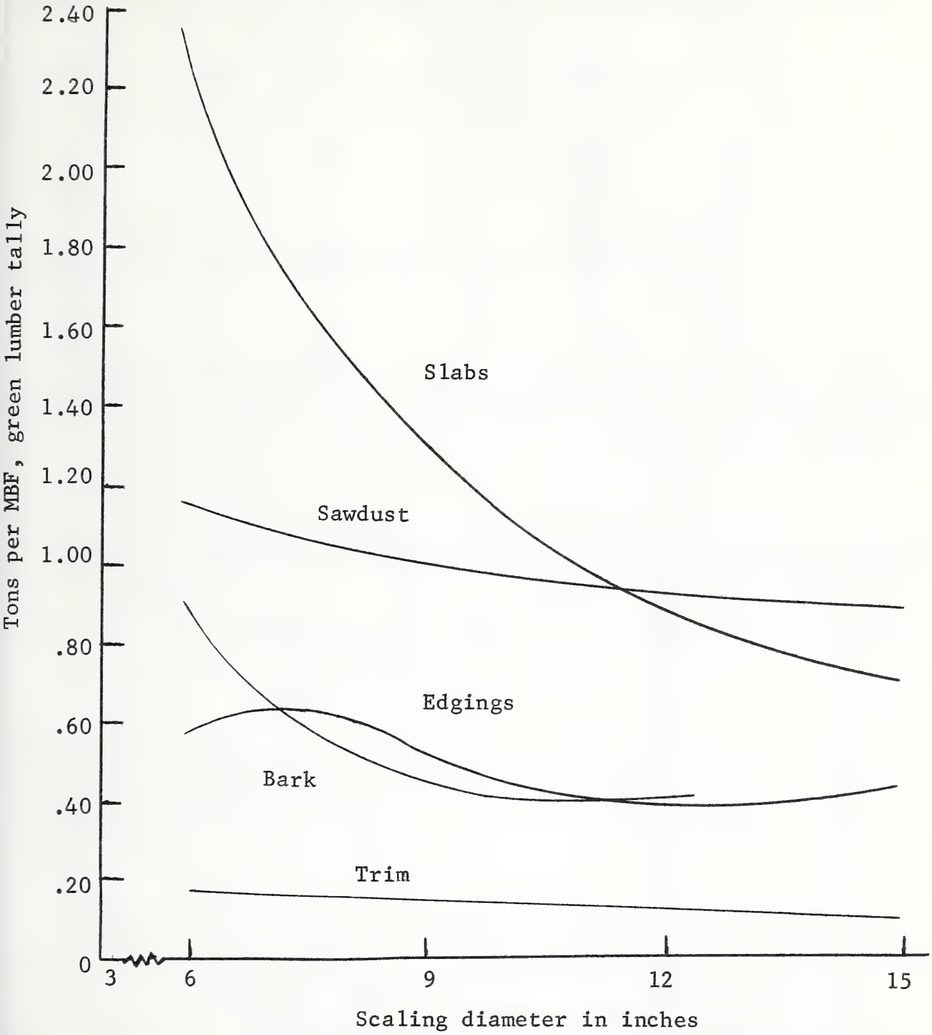

FIGURE 8.—Conversion factors for softwood residue at Georgia sawmills. (Adapted from Page, R. H., and J. R. Saucier. 1958. Survey of wood residue in Georgia. Ga. Forest Res. Council, Resource-Industry Rpt. 1.)

TABLE 82.—Residue yields in tons per thousand board feet of lumber tally by log diameter and residue source

Scaling diameter	Chippable residue					
	Debarked logs		Debarked slabs and edgings		Debarked slabs only	
	Bark-free slabs and edgings	Screened chips	Bark-free slabs and edgings	Screened chips	Bark-free slabs	Screened chips
In.	Tons per thousand board feet					
5	3.25	3.10	2.65	2.50	2.10	2.00
6	2.90	2.75	2.30	2.20	1.90	1.80
7	2.50	2.40	2.00	1.90	1.65	1.55
8	2.20	2.10	1.80	1.70	1.40	1.35
9	1.90	1.80	1.50	1.45	1.20	1.15
10	1.65	1.55	1.30	1.25	1.05	1.00
11	1.40	1.35	1.15	1.10	0.95	0.90
12	1.20	1.15	0.95	0.90	0.80	0.75
13	1.05	1.00	0.85	0.80	0.70	0.65
14	0.95	0.90	0.75	0.70	0.65	0.60
15	0.85	0.80	0.70	0.65	0.50	0.50

Source: Applefield, Milton. 1960. The production and marketing of pine wood residues by small sawmills. Texas Forest Serv. Bull. 50.

TABLE 83.—Proportion of slab volume and weight in wood and bark for shortleaf pine[1]

Scaling diameter	Volume		Weight	
	Wood	Bark	Wood	Bark
In.	Percent			
5	78	22	86	14
6	76	24	85	15
7	74	26	84	16
8	72	28	83	17
9	70	30	81	19
10	69	31	80	20
11	67	33	79	21
12	65	35	77	23
13	63	37	76	24
14	61	39	74	26
15	60	40	73	27
16	58	42	71	29
17	56	44	68	30
18	54	46	68	32
19	52	48	67	33
Average	65	35	77	21

[1] Average moisture content of bark was 29 percent. Average moisture content of wood was 54 percent of the green weight.

Source: Todd, A.S., Jr., and Walter C. Anderson. 1955. Size, volume, and weight of pine slabs and edgings in the South Carolina Piedmont. U.S. Forest Serv., Southeast. Forest Exp. Sta., Sta. Paper 49.

Whole Log Utilization

The following products and losses were reported as average values from one year's operation:[4]

Utilization channel	Percent of log volume
Bark	5.0
Sawdust and trim	16.2
Planer shavings	12.8
Shrinkage	4.6
Slabs and edgings	23.0
Finished lumber	38.4

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[4] Reported by one southern pulp and paper manufacturer that is integrated with sawmill operations. Data were obtained based on lumber manufacture from loblolly and shortleaf pine.

TABLE 84.—Volume of bark-free wood in a cord of pine slabs, by diameter and species[1]

Average scaling diameter	Species		
	Longleaf and shortleaf	Loblolly	Slash
In.	Cubic feet		
6	60	58	57
8	57	54	51
10	55	50	47
12	51	46	43
14	48	43	39
16	46	39	36
18	43	36	32
20	40	32	29

[1] Measurements of 18 sample piles of southern pine slabwood indicated that a standard cord of slabs contained 79 cubic feet of solid wood and bark. An approximate figure for all southern pines is 50 cubic feet of solid wood per standard cord.

Source: Todd, A. S., Jr. 1955. How much wood in a cord of pine slabs? U.S. Forest Serv., Southeast. Forest Exp. Sta., Res. Note 87.

TABLE 85.—Yield of slabs, edgings, and trim per thousand board feet at circular pine sawmills

Average scaling diameter	Log scale		Green lumber tally
	International	Doyle	
In.	Tons per thousand board feet		
7	2.15	7.24	2.40
8	1.80	4.90	2.08
9	1.55	3.30	1.80
10	1.30	2.30	1.56
11	1.10	1.74	1.34
12	0.95	1.48	1.16

Source: Lehman, John W. 1958. Utilizing pine sawmill residue for pulp chips. Tennessee Valley Auth. Div. of Forest Relations. Rpt. No. 223-58.

Chips

The following figures, based on average weights of secondary sawmill products, are computed on the basis of the moisture content at which the material is ordinarily utilized, and without artificial drying or extensive air-drying:[5]

One ton of air-dry chips may be recovered from 0.83 standard cords of wood. One standard, stacked cord of pulpwood yields 1.20 tons of air-dry chips.

Chippable residue from the manufacture of:

One MBF, lumber scale, yields 1.20 tons, green chips.
One MBF, Doyle scale, yields 1.60 tons, green chips.

Green chips from southern pine sawmill residue weigh 24 pounds per cubic foot of gross space occupied. Green chips from southern pine plywood clippings weigh 20 pounds per cubic foot of gross space occupied.

In a study of East Texas mills, Kramer (1957) presented chip yields in terms of pounds of chips per board foot of gross log scale (Table 86). For example, if the average log scaling diameter is 10 inches, then the chip yield will be about 4.6 pounds per board foot of log scale by the Doyle rule, or about 4,600 pounds of chips per MBF Doyle scale. These figures are for mills where no green products other than lumber are produced. The type of headrig may cause a ± 10 percent variation in chip yield.

Chip yield per unit of lumber tally was expressed in regression form by Row, Fasick, and Guttenberg (1965) from data obtained through the application of linear programming to operations research. Logs varied in diameter, grade, density, and position in the tree. The following regressions were computed:

$$\text{Butt logs: } W = 2.12\,DL - 9.75L$$

$$\text{Upper logs: } W = 1.63\,DL - 4.47L$$

where W = weight in pounds; L = length in feet; and D = scaling diameter in inches.

Based on these regressions, Tables 87 and 88 show chip weights for butt and upper logs by scaling diameter and log length. Log rule formulae were applied to determine the weight of chips in tons per MBF log scale, International rule, as shown in Tables 89 and 90.

To convert chip yields in tons per MBF International rule to other log

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[5] Data obtained from southern pine industry averages.

TABLE 86.—Yield of pine residue pulp chips by scaling diameter and log rule

Average scaling diameter	Chip yield per board foot gross log scale		
	Doyle	Scribner	International
In.	Pounds		
7	---	4.8	4.3
8	9.8	4.3	3.7
9	6.6	3.7	3.1
10	4.6	3.2	2.6
11	3.5	2.8	2.2
12	2.9	2.5	1.9
13	2.5	2.2	1.7
14	2.2	1.9	1.6
15	2.1	1.7	1.5

Source: Kramer, Paul R. 1957. The yield of sawmill residue pine pulp chips by sawlog size. Texas Forest Serv. Circular 56.

TABLE 87.—Weight of usable chips from residue of butt logs[1]

Scaling diameter	Log length in feet				
	8	10	12	14	16
In.	Pounds				
8	57.68	72.10	86.52	100.94	115.36
10	91.60	114.50	137.40	160.30	183.20
12	125.52	156.90	188.28	219.66	240.48
14	159.44	199.30	239.16	279.02	318.88
16	193.36	241.70	290.04	338.38	386.72
18	227.28	284.10	340.92	397.74	454.56
20	261.20	326.50	391.80	457.10	522.40
22	295.12	368.90	442.68	516.46	590.24
24	329.04	411.30	493.56	575.82	658.08
26	362.96	453.70	544.44	635.18	725.92

[1] Obtained by application of formula: $W = 2.12DL - 9.75L$ (Row, Fasick, and Guttenberg, 1965). Values above 18 inches are estimated.

TABLE 88.—Weight of usable chips from residue of upper logs[1]

Scaling diameter	Log length in feet				
	8	10	12	14	16
In.	Pounds				
8	68.56	86.40	102.84	119.98	137.12
10	94.64	119.60	141.96	165.62	189.28
12	120.72	151.60	181.08	211.26	241.44
14	146.80	184.20	220.20	256.90	293.60
16	172.88	216.80	259.32	302.54	345.76
18	198.96	249.40	298.44	348.18	397.92
20	225.04	282.00	337.56	393.82	450.08
22	251.12	314.60	376.68	439.46	502.24
24	227.20	347.20	415.80	485.10	554.40
26	303.28	379.80	454.92	530.74	606.56

[1] Obtained by application of formula: $W = 1.63DL - 4.47L$, (Row, Fasick, and Guttenberg, 1965). Values above 18 inches are estimated.

TABLE 89.—Tons of chips, from butt log residue, per MBF International log scale[1]

Scaling diameter	Log length in feet				
	8	10	12	14	16
In.	Tons				
8	1.923	1.802	1.730	1.442	1.442
10	1.527	1.636	1.527	1.457	1.409
12	1.395	1.426	1.344	1.292	1.266
14	1.157	1.246	1.196	1.213	1.181
16	1.137	1.099	1.116	1.091	1.074
18	1.033	1.015	1.003	0.994	0.988
20	0.967	0.933	0.956	.914	.901
22	.868	.858	.851	.847	.831
24	.802	.806	.796	.778	.774
26	.756	.744	.736	.730	.726

[1] Derived by the application of the International ¼-inch log rule to the values in Table 87, weight of chips from residue of butt logs. Values above 18 inches are estimated.

rule bases, first obtain the board foot values for both the International and the desired log rule at the appropriate scaling diameter and log length (see Tables 27, 28, and 29). Tons of chips per MBF International times board foot value for the International rule divided by the board foot value for the desired log rule will give chip yields in tons per MBF for the desired log rule.

Expressions of chip yields per unit of raw material are relative measures, and there are several variables, encountered in converting log scale volumes into values of chips, that prevent consistently accurate determinations:

1. Board foot-log scales do not indicate solid wood content.
2. Chip recovery varies with type of debarking prior to chipping.
3. Volumes of screened chips recovered from a log depend on both chipping and screening processes.
4. Some chippers produce abnormal percentages of oversize and undersize chips.
5. Species and storage conditions of logs affect the final chip yields.
6. Log quality and scaling practices affect the final yield of chips.

An analysis of chip sizes received at a southern pine pulp mill is shown in Table 91. The chips came from mills with various types of barkers and head-rigs, and the values presented are representative of chip sizes that may be expected over a wide range of utilization practices.

TABLE 90.—Tons of chips, from upper log residue, per MBF International log scale[1]

Scaling diameter	Log length in feet				
	8	10	12	14	16
In.			Tons		
8	2.285	2.160	2.057	1.714	1.714
10	1.577	1.700	1.577	1.506	1.456
12	1.341	1.378	1.293	1.243	1.271
14	1.129	1.151	1.101	1.117	1.087
16	1.017	0.985	0.997	0.976	0.960
18	0.904	.891	.878	.870	.865
20	.833	.806	.805	.788	.776
22	.738	.732	.724	.720	.707
24	.676	.681	.671	.656	.666
26	.632	.623	.615	.610	.606

[1] Derived by the application of the International ¼-inch log rule to the values in Table 88, weight of chips from residue of upper logs. Values above 18 inches are estimated.

TABLE 91.—Analysis of chip size by Williams chip classifier[1]

Chip size	Volume	Acceptability
	Percent of total	
On 1-inch screen	3.16	Oversize
Through 1-in. screen, on ¾-in. screen	10.60	Acceptable
Through ¾-in. screen, on ½-in. screen	28.75	Acceptable
Through ½-in. screen, on ⅛-in. screen	55.16	Acceptable
Dust	2.20	Undersize (Fines and sawdust)
Average moisture content	51.87	
Average bark volume	0.81	

[1] Data compiled from 3-month averages for chips received at a kraft pulp mill from 19 southern pine sawmills in the Southern United States.

Sawdust

Recent utilization of sawdust materials for mulches and composition products has resulted in the determination of certain converting factors by one southern pine manufacturer. All sawdust was measured at 8 percent moisture content, after being kiln-dried.

Sawdust ground through ¼-inch screen, unsifted = 16 lbs./cu. ft.
Sawdust minus 10-mesh U.S. Standard screen = 15 lbs./cu. ft.
Sawdust minus 20-mesh U.S. Standard screen = 18 lbs./cu. ft.

Row, Fasick, and Guttenberg (1965) developed a regression of scaling diameter and log length to the weight of sawdust produced in lumber manufacture: $W = 0.0680D^2L$, where W = sawdust weight in pounds, D = log scaling diameter, and L = log scaling length. Based on this equation, Tables 92 and 93 show chip weight in pounds and in tons per MBF Doyle scale, respectively.

To convert chip yields in tons per MBF Doyle to other log rules, first obtain the board foot values for both the Doyle rule and for the desired log rule at the appropriate scaling diameter and log length (see Tables 27, 28, 29). Tons of chips, Doyle scale, times the board foot value Doyle rule, divided by the board foot value for the desired log rule equals tons of chips per MBF for the desired log rule.

TABLE 92.—Weight of sawdust from sawmill residue[1]

Scaling diameter	Log length in feet 8	10	12	14	16
In.	Pounds				
8	34.82	43.52	52.22	60.93	69.63
10	54.40	68.00	81.60	95.20	108.80
12	78.34	97.92	117.50	137.09	156.67
14	106.62	133.28	159.94	186.59	213.25
16	139.26	174.08	208.90	243.71	278.53
18	176.26	220.32	264.38	308.45	352.51
20	217.60	272.00	326.40	380.80	435.20
22	263.30	329.12	394.94	460.77	526.59
24	313.34	391.68	470.02	548.35	626.69
26	367.74	459.68	551.62	643.55	735.49

[1] Obtained by application of formula: $W = 0.068D^2L$ (Row, Fasick, and Guttenberg, 1965). Values above 18 inches are estimated.

TABLE 93.—Weight of sawdust from sawmill residue per MBF Doyle log rule[1] [2]

Scaling diameter	Weight	Scaling diameter	Weight
In.	Tons/MBF	In.	Tons/MBF
8	2.18	18	.90
10	1.51	20	.85
12	1.22	22	.81
14	1.07	24	.78
16	0.97	26	.76

[1] Derived by the application of the Doyle log rule to values in Table 92. Values above 18 inches are estimated.

[2] The effect of log length had almost no effect on the amount of sawdust produced per MBF log scale. The above table values apply to any scaling length from 8 to 16 feet.

Bark

Recovery of southern pine bark from mill operations is becoming increasingly important in the South. Bark may be economically recovered as a primary raw material through any number of processes and used either alone or in combination with other residues to produce useful and marketable products.

Given the volume of bark that may be salvaged from wood-using processes, average recoveries of the product by weight and volume can be predicted for future operations. Market analysis will then determine if bark, as a raw material, can be economically utilized.

The volume of stacked bark is greater than the volume of actual bark substance, since it includes the volume of the bark interstices.

Rough bark weighs less per unit of volume than smoother bark from top cuts.

A study conducted by one southern pine firm revealed weight-volume ratios for green bark of loblolly pine:

100 lbs. green bark occupies 3.8 cubic feet of space.
1 cubic foot of green bark weighs 26.3 pounds.

Bark weight varies more among plots than among trees within plots, but variations are greater among trees than among logs of the same tree. Volume-weight ratios for butt logs, however, decrease with increasing tree height.

Sawlogs—Bark weights for southern pine logs are given in Table 94. Data are based on a linear programming analysis in southern pine operations (Guttenberg, Fassnacht, and Siegel, 1960) and apply only to loblolly and shortleaf pine logs.

The effects of log length and diameter on bark weight were determined from a linear programming study (Row and Guttenberg, 1966), and a regression equation was developed to predict bark weight as a percent of total log weight. Table 95 shows the application of these data to loblolly and shortleaf pine logs having average form and taper and should be restricted to use with these species.

Bark weights for 16-foot longleaf and slash pine logs are shown in Table 96.

TABLE 94.—Weight of southern pine bark by scaling diameter and log length[1]

Scaling diameter	Log length in feet 8	10	12	14	16
In.	Pounds				
8	13.09	16.37	19.65	22.93	26.20
10	19.19	23.99	28.79	33.59	38.38
12	26.41	33.01	39.61	46.22	52.82
14	35.16	43.44	52.12	60.81	69.50
16	44.22	55.28	66.34	77.39	88.45
18	54.82	68.52	82.23	95.93	109.64
20	66.54	83.28	99.81	116.45	133.09
22	73.39	99.24	119.09	138.94	154.78
24	93.27	116.71	140.05	163.40	186.74
26	108.47	135.58	162.71	189.82	216.94

[1] Obtained by application of formula: $W = .0639DL + .0176D^2L$ (Row, Fasick, and Guttenberg, 1965). Values above 18 inches are estimated.

Pulpwood—An average value for the amount of pulpwood lost in bark removal is 11 percent of the green weight.[6] One standard cord of pulpwood contains 488 pounds of bark in the green condition, and 357 pounds of bark in the oven-dry condition. Data were compiled from industry and published averages, Figure 9, to show bark weight variations due to the percent of solid wood volume per rough cord. Information was based on average values for four major species of southern pine pulpwood.

Residue—Bark from sawmill residue weighed 19¾ pounds per cubic foot at 39 percent moisture content after being passed through a hog.[7] The high moisture content of the bark was attributed to sprinkling of logs before barking.

In a study of East Texas firms, Weldon (1966) revealed characteristics of bark obtained from different types of utilization:

Industry	Bark moisture content	Oven-dry wood in residue bark
	Pct.	Pct.
Sawmills	64.3	1.8
Pulpmills	52.9	10.3
Polemills	75.5	50.8

From the same study, unpublished data show bark weight as a function of total green weight by average small-end diameter of pulpwood, Figure 10.[8]

Predicting Available Bark Residue—For predicting expected bark residues from log volumes, the values in Table 94 have been converted to tons of bark per MBF International rule, since this rule closely approximates actual lumber tally (Table 97). To convert tons of bark per MBF International into other scales:

1. Determine the board foot volume, International, for the desired diameter and length from Table 28.
2. Determine the board foot volume for the desired log rule based on the same diameter and log length. Use either Table 27 for Doyle or Table 29 for Scribner volumes.
3. Tons of bark per MBF International times board foot volume, International, divided by the board foot volume for the desired log rule at the appropriate scaling diameter and length equals tons of bark per MBF for the desired log rule.

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[6] Data obtained from averages of 12 firms processing pulpwood.

[7] A hog is a machine used for grinding materials to a specified particle size. Data obtained from one bark processor.

[8] Data obtained from personal interview with Paul Kramer, Texas Forest Service.

TABLE 95.—Bark weight as a percent of total green log weight for loblolly and shortleaf pine[1]

Scaling diameter	Log length in feet		
	12	16	20
In.		Percent	
6	9.8	10.2	10.5
9	9.4	9.7	10.0
12	9.1	9.4	9.6
15	8.9	9.1	9.4
18	8.8	9.0	9.2

[1] Obtained by application of formula: $W = 0.0233D^2L + .00645DL^2$ (Row and Guttenberg, 1966).

TABLE 96.—Weight of bark per MBF of lumber tally by species[1]

Scaling diameter	Species	
	Longleaf	Slash
In.	Pounds	
5	2010	----
6	1630	1800
7	1400	1660
8	1230	1530
9	1120	1390
10	1040	1260
11	990	1120
Weighted avg.	1281	1400

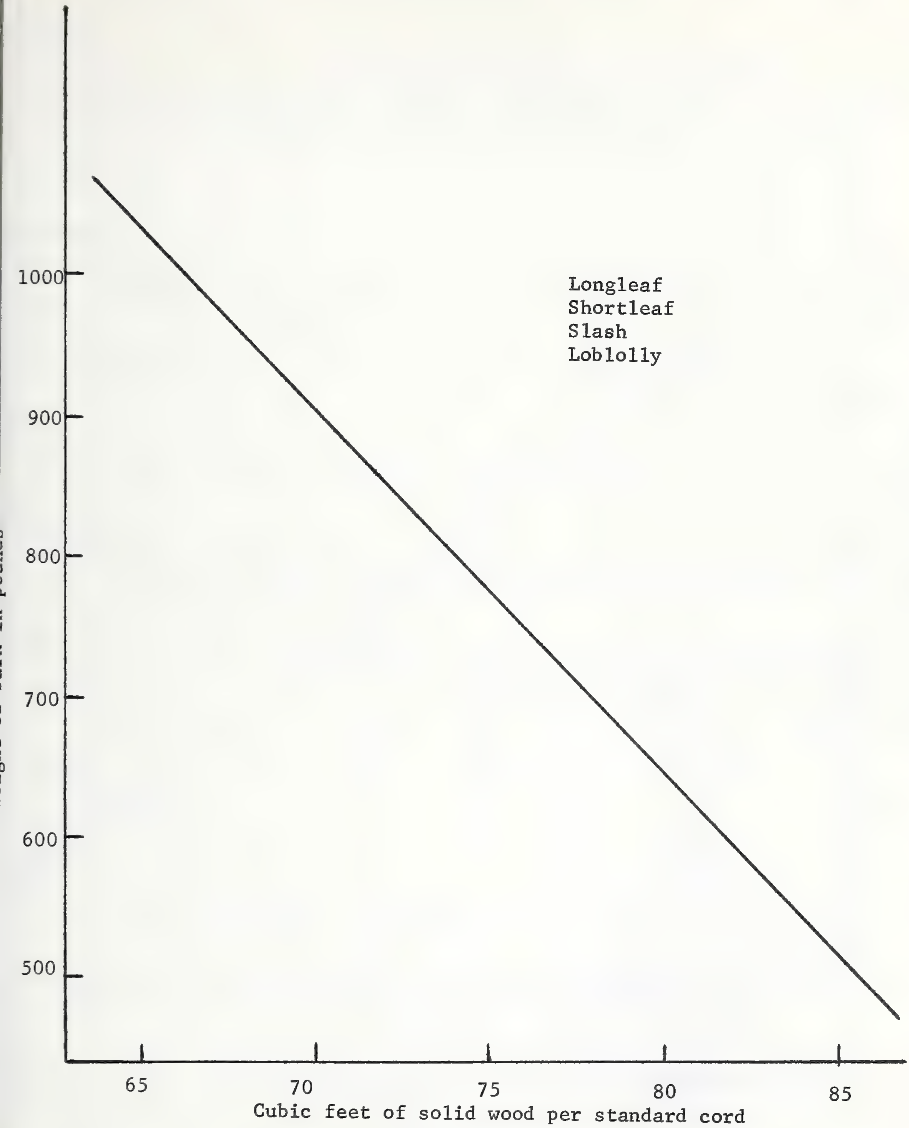
[1] Data read from curves as average values for 16-foot logs.

Source: Page, Rufus H., and Paul J. Bois. 1961. Buying and selling southern yellow pine sawlogs by weight. Georgia Forest Res. Council Rpt. 7.

TABLE 97.—Weight of bark in tons per MBF, International log rule[1]

Scaling diameter	Log length in feet				
	8	10	12	14	16
In.			Tons		
8	.436	.409	.393	.327	.327
10	.319	.342	.320	.305	.295
12	.293	.300	.283	.272	.278
14	.270	.272	.261	.264	.257
16	.260	.251	.255	.250	.246
18	.249	.245	.242	.239	.238
20	.246	.238	.238	.233	.229
22	.234	.231	.229	.228	.224
24	.228	.229	.226	.221	.219
26	.226	.222	.220	.218	.217

[1] Data derived from equation by Row, Fasick, and Guttenberg (1965).



IGURE 9.—Weight of southern pine pulpwood bark compared to the solid wood content er standard cord.

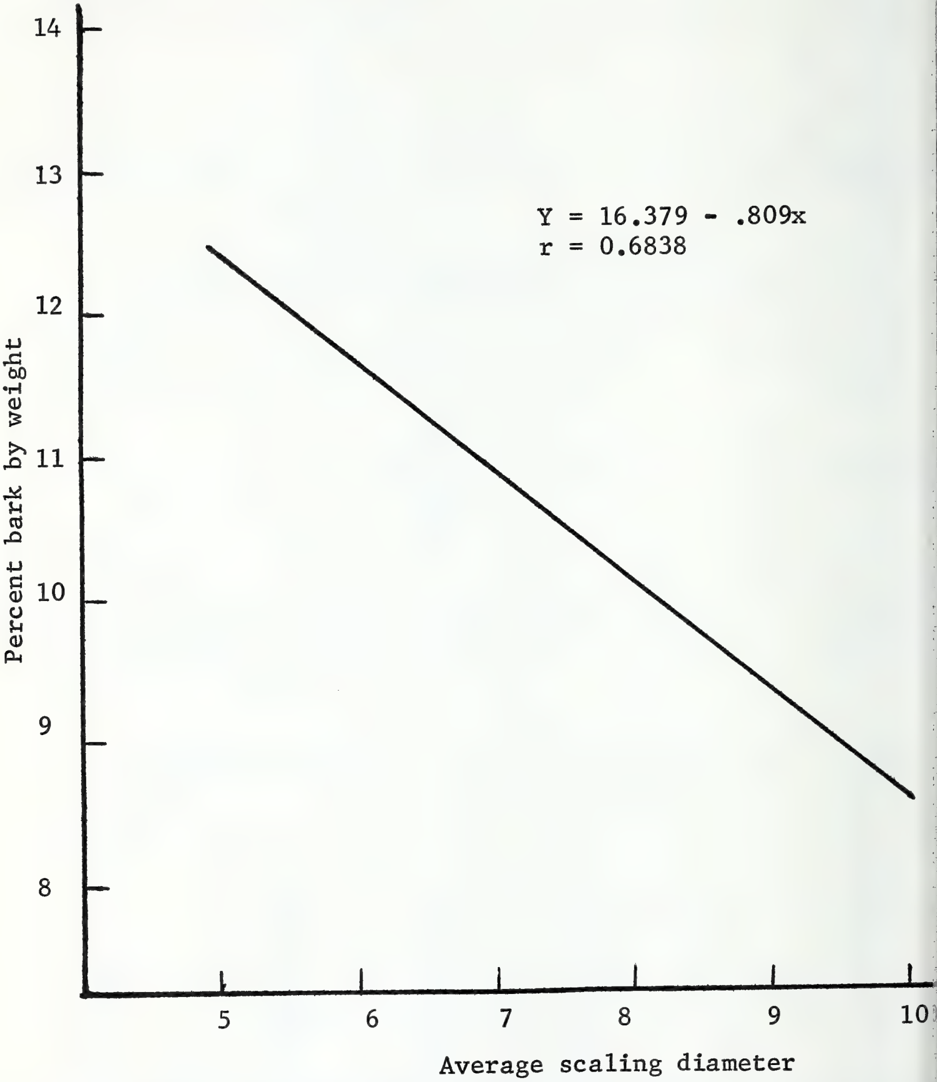


FIGURE 10.—Bark weight as a percent of total green weight by average log diameter. (Adapted from Kramer, Paul R. 1966. Data obtained from unpublished bark recovery study. Texas Forest Service.)

Minor Forest Products

Handles

Round handles may be produced by turning and sanding 1-inch by 1-inch squares cut from salvaged slabs and edgings. Residue from the manufacture of one MBF, Doyle log scale, provides 120 1-inch by 1-inch squares that are 8 feet long.

Excelsior

One standard cord of pulpwood yields one ton of excelsior, with a range of from 1,800 to 2,200 pounds depending upon size of bolts, size of strands of excelsior, volume of loss due to defects, and the kind of wood used. Excelsior moisture content at the time of use is normally 8 percent.

Gum

One standard barrel of crude gum weighs 435 pounds.

Fiberboard

The following table concerning the manufacture of fiberboard was provided by one southern firm:

Product	Thickness	Composition Pine	Composition Oak	Kiln weight per M Sq. Ft.[1]	Board density
	In.	Pct.	Pct.	Lbs.	Lbs./Sq. Ft.
Roofing	.5	100	0	665	15
Roofing	.75	75	25	1079	15
Sheathing (Plain)	.5	66	34	----	16
Sheathing (Coated)	.5	66	34	720	16
Roofing	1.0	100	0	1116	15
Tile	.5	50	50	838	17
Board	.5	---	---	785	17

[1] Average kiln weight based on 6 percent moisture content.

A workable average for the manufacture of fiberboards in the South is one ton of chips for every 1.26 M. Sq. Ft. of fiberboard manufactured.

Producing Quality Beef With Grass and Grain

JOHN C. CARPENTER, JR., R. H. KLETT, PAUL B. BROWN
AND GEORGE L. ROBERTSON

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AND AGRICULTURAL AND MECHANICAL COLLEGE
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Preface

There is an increasing interest in Louisiana and in the Southeastern states in ways of producing more quality slaughter beef. The use of improved pastures makes it possible to produce more beef per acre with the steer fattening program than with a cow-calf plan. Previous work at this station has shown that the feeding of grain, either on grass or in drylot, is necessary to attain slaughter grades of U.S. Good or Choice.

Currently the demand in Louisiana markets is for carcasses weighing from 450 to 650 pounds, grading Good to Choice, with a minimum amount of external fat.

This bulletin compares three programs for producing high-quality beef utilizing high-quality forage, with limited amounts of grain. These programs are described as follows:

(1) Feed grain on grass for 300 to 350 days.
(2) Graze 215 to 225 days and feed grain on grass for 90 to 130 days.
(3) Graze 330 to 340 days and feed in drylot for 112 days.

These programs take advantage of our natural resources by utilizing a maximum amount of grass and a minimum amount of grain. These systems of finishing beef cattle might be described as "low-risk" systems, since they require a minimum amount of labor and purchased inputs.

Producing Quality Beef With Grass and Grain

JOHN C. CARPENTER, JR.,[1] R. H. KLETT,[2] PAUL B. BROWN[3]
AND GEORGE L. ROBERTSON[4]

Summary

Research at the Northeast Louisiana Experiment Station has shown that quality beef carcasses may be produced by feeding grain either as a pasture supplement or in drylot following a period of grazing. These carcasses averaged 510 to 601 pounds and had sufficient marbling to grade U.S. Standard to Choice with only a thin rind of external fat. The fat was white except for a very few cases each year, and these were not yellow enough to be objectionable to packers.

Three programs were used in producing these slaughter steers. Each program began in the fall with weanling beef calves weighing 422 to 463 pounds and grading Standard to Good. At the close of each program the steers weighed 864 to 1,073 pounds and graded U.S. Standard to Choice. Carcasses were observed in two of the three years.

In Program No. 1, concentrates were fed to steer calves grazing pastures for 300 to 350 days. Approximately one ton of feed was required per steer. Concentrates were fed to one group at a constant level of 8 pounds per head daily and to the other group at 1 pound per head daily for each 100 pounds of live weight. Thus the amount of concentrates fed to the latter group was increased with each 100 pounds increase in body weight. The steers fed at the 1 percent level carried a higher degree of finish as observed after approximately 220 days in each trial. Forty-five percent of the steers in this group graded Choice when slaughtered as compared with 20 percent in the group fed at a constant level during the trial. All carcasses exhibited superior marbling and rind fat that was fairly thin and white.

In Program No. 2 weanling calves were grazed approximately 220 days (from October to May) without concentrates. Beginning in May they were fed 1.5 pounds of concentrates per 100 pounds of body weight while grazing common Bermudagrass pastures for approximately 128 days. Approximately 1,500 pounds of concentrates were required per steer. The carcasses produced in this program were also acceptable. They exhibited white fat, had sufficient marbling to grade U.S. Standard to Good, and had exceptionally thin rind fat.

The weanling calves in Program No. 3 were grazed 330 to 340 days with no supplemental grain and were fed for a finishing period of 112 days in drylot. In these trials, an average of approximately 1,842 pounds

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of concentrates and 566 pounds of hay were fed per steer. Carcasses had thin, white rind fat and sufficient marbling to grade Good to Choice. Approximately one-third of the carcasses produced in this program graded U.S. Choice.

Program No. 1 produced a greater number of Choice carcasses, which exhibited superior marbling, than did the other two programs. Program No. 2 produced carcasses with thinner rind fat. All three programs produced Good to Choice carcasses each year that were highly acceptable to the packers.

Previous Work

Research at this station during 1961-1963 showed that, to obtain a slaughter grade of U.S. Good, it is necessary to feed grain to steers while grazing Coastal Bermudagrass pastures (*1*).[5]

Investigations at the North Carolina Agricultural Experiment Station (*8*) showed that one of the best ways to increase returns from a cattle fattening program is to include high-quality pasture in the program. Indications were that concentrates should be fed at the level of 0.8 to 1 percent of the animal's body weight. In that work salt was as effective as yellow grease in controlling feed intake.

Workers at the Florida Experiment Station (*2*) showed that either orally administered (10 milligrams daily) or implanted (24 mg. per steer) stilbestrol can be used in fattening of steers. Carcass grades were occasionally lowered by a 36-mg. implant per steer to grazing animals. No more than a 24-mg. implant of stilbestrol per steer was recommended for cattle fed on pasture.

Research workers at Clemson (*5*) reported a one-third higher carcass grade from drylot fed steers than from steers fed grain on pasture. Ratings of meat (steaks and roasts) by purchasers showed no significant difference in preference for either drylot or pasture fed cattle when the meat was rated on the basis of taste, tenderness, and aroma.

Virginia workers (*6*) found that feeding 22.3 bushels of coarsely ground corn per head to grazing steers from July 1 to October resulted in a live slaughter grade of Good. Steers grazing pasture alone graded Standard.

Research data (*3* and *4*) collected at the Tennessee Station indicated that high-quality winter and spring pastures can be used as an economical source of feed in a yearling slaughter steer program if followed by a short drylot feeding period (70 days). During this feeding period the slaughter grade of the cattle increased from Standard to Good, which resulted in an increased value per hundredweight of more than $5.50.

Georgia workers (*7*), while studying alternative cattle feeding systems, reported more profits from a combination of grazing winter annuals and drylot feeding or from grazing alone than from drylot feeding alone. Their most profitable system included winter grazing of annual pastures for 120 days followed by a 120-day drylot feeding period. The least profitable system was drylot feeding for 180 days.

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[5] Italic numbers in parentheses refer to Literature Cited, Page 11.

General Procedure

Preparation of Pastures

Pastures used in these studies included fescuegrass, ryegrass, Coastal Bermudagrass, common Bermudagrass, Johnsongrass, and a forage sorghum (Lindsey 77F).

Fescuegrass pastures were on established plots with a good stand of grass. These pastures were topdressed each September with 67 pounds of nitrogen per acre. Another application of 33.5 pounds of nitrogen per acre was made in February or March of each year.

Ryegrass pastures were seeded on a prepared seedbed each September. Just prior to seeding, 67 pounds of nitrogen was disked in. Common ryegrass was seeded at the rate of 45 pounds per acre and cultipacked. A topdressing of 33.5 pounds of nitrogen per acre was applied each February or March.

Coastal Bermudagrass pastures were topdressed each April with 67 pounds of nitrogen per acre, and another 33.5 pounds of nitrogen was applied to each acre in July or August.

Forage sorghum (Lindsey 77F) was seeded at the rate of 30 to 40 pounds per acre on a prepared seedbed during May each year, following fertilization with 67 pounds of nitrogen per acre.

Stocking rates varied from one to two animals per acre depending on the amount of grain being fed and the amount of forage available. All plots furnished abundant high-quality forage.

Handling of Cattle

Weanling beef steers for each of the three programs were purchased each year in October. These calves ranged in weight from 422 to 463 pounds, and in grade from Medium to Good. All calves were wormed soon after purchase and again in May of the following year. They were sprayed to control lice, and backrubbers were provided to control flies. Each steer received a 12-mg. implant of diethylstilbestrol in October and a 24-mg. implant in May. Salt and minerals were fed free choice.

After being randomly assigned to treatment groups, all cattle were on winter and spring grazing crops from October until May. Only the animals in Program No. 1 received supplemental concentrates during the period from October to May. (Lots 1 and 2 on Program No. 1 were grazed together and received 8 pounds of 12 percent protein fattener pellets per head per day, while Lot 3 received 1 pound of a mixture containing equal parts of 12 percent fattener pellets and hominy per 100 pounds of body weight per day.)

In May of each year the cattle were allotted (on the basis of previous treatment and rate of gain) to treatment groups receiving varying amounts of concentrates and/or improved summer pasture as follows:

Program No. 1

Lot 1 (5 steers) continued to receive 8 pounds of 12 percent fattener pellets.

Lot 2 (6 steers) received 8 pounds of 12 percent fattener pellets plus 3.5 pounds of hominy.

Lot 3 (10 steers) received 1 pound of a mixture of equal parts of 12 percent protein fattener pellets and hominy per 100 pounds of body weight per day.

Program No. 2

Lot 1 (8 steers) received 1.5 pounds of 12 percent fattener pellets per 100 pounds of body weight per day.

Lot 2 (8 steers) received 1.5 pounds of a mixture of equal parts of 12 percent pellets and hominy per 100 pounds of body weight.

Program No. 3

All cattle were on temporary grazing (Lindsey 77F forage sorghum) from May until mid-September. Beginning in September all cattle were fed for 112 days in drylot as one group; they received 2 pounds of a mixture of equal parts of 12 percent pellets and hominy per 100 pounds of body weight per day.

Program No. 1 — Limited Feeding on Pastures

Procedure

This program was designed to compare two groups of calves fed limited amounts of grain over a period of some 312 days. Two groups (Lots 1 and 2) were fed together during the first 222 days of the trial (Phase I) and received a constant amount of concentrates (8 pounds per head per day) which consisted of 12 percent protein fattener pellets containing 52 percent grain. Lot 3 was fed separately and received 1 pound of concentrates per 100 pounds of body weight. The concentrate supplement for Lot 3 during this period consisted of equal parts of 12 percent fattener pellets and hominy.

The calves in Lots 1 and 2 grazed Coastal Bermudagrass from October to December. Fescue or ryegrass pastures were grazed from then until May, and Coastal Bermudagrass provided the grazing for the final 90 days of the trial. The pasture used for Lot 3 was a 10-acre plot which contained fescue, ryegrass, Johnsongrass, and common Bermudagrass.

During the last 90 days (Phase II) of this study Lot 1 continued to receive 8 pounds of fattener pellets per head per day, while Lot 2 received an additional 3.5 pounds of hominy. Lot 3 continued to receive the hominy pellet mixture at the rate of 1 pound per 100 pounds of body weight.

Results and Discussion

Results of feeding and grazing in Phase I are presented in Table I. There were no significant differences in total gain per steer or average daily gain when Lots 1, 2, and 3 were compared. However, there was a trend for Lots 1 and 2 to have a lower rate of gain even though they consumed more feed than the steers fed 1 percent of their body weight. There was a tendency for the steers in Lot 3 to fatten earlier and carry a higher degree of finish in May than steers in the other lots.

During Phase II, the steers fed approximately 8 pounds of concentrates per day had the lowest rate of gain; however, they consumed less feed than those in Lot 3 (Table 2). Steers in Lot 2 consumed 11.2 pounds of feed per day and made the highest daily rate of gain (1.74 pounds) but were the least efficient when considering pounds of grain per pound of gain.

Pooled data for both phases of the study are presented in Table 3. Steers in Lot 3 exhibited a higher rate of gain on less feed than the other lots. Steers in Lot 3 consumed 2,143 pounds of concentrates during the 312-day feeding period and made a total gain of 548 pounds. Steers in Lots 1 and 2 consumed 2,215 and 2,552 pounds of concentrates and made total gains of 507 and 529 pounds, respectively. Steers fed 1 percent of their body weight required only 3.90 pounds of concentrates per pound of gain, whereas those in Lots 1 and 2 consumed 4.36 and 4.81 pounds of concentrates per pound of gain, respectively.

Steers fed 1 percent of their body weight were heavier at slaughter than those in Lots 1 and 2. Cattle in Lot 3 were slaughtered at what is considered the ideal slaughter weight necessary to produce a desirable carcass grading Good to Choice and having a minimum amount of waste fat.

Lots 1 and 2 were stocked at a higher rate per acre and were

TABLE 1.—Two-Year Average Results of Feeding and Grazing Fescue-Ryegrass Pastures (October-May; 222 Days)

Treatment	Pasture plus 8 lb. concentrates	Pasture plus 1 percent concentrates
Lot No.	1, 2*	3
Avg. number of animals per yr.	11	10
Steers per acre	1.5	1.0
Final weight, lb.	829	850
Initial weight, lb.	459	450
Gain per steer, lb.	370	400
Daily gain per steer, lb.	1.67	1.80
Concentrate intake/hd./day, lb.	6.94	5.99
Concentrate intake/lb. gain, lb.	4.16	3.33

*Lots 1 and 2 fed together.

TABLE 2.—Two-Year Average Results of Summer Feeding and Grazing (May-September; 90 Days)

Treatment	Pasture plus 8 lb. concentrates	Pasture plus 11.5 lb. concentrates	Pasture plus 1 percent concentrates
Lot No.	1	2	3
Avg. number of animals/yr.	5	6	10
Steers per acre	2.0	2.0	1.0
Final weight, lb.	966	988	998
Initial weight, lb.	826	831	850
Gain per steer, lb.	140	157	148
Daily gain per steer, lb.	1.56	1.74	1.64
Conc. intake/hd./day, lb.	7.50	11.20	9.00
Conc. intake/lb. gain, lb.	4.81	6.44	5.49

TABLE 3.—Two-Year Average Results of Feeding and Grazing Fescue-Ryegrass and Bermudagrass Pastures (October-September; 312 Days)

Treatment	Pasture plus 8 lb. concentrates	Pasture plus 8-11.5 lb. concentrates*	Pasture plus 1 percent concentrates
Lot No.	1	2	3
Avg. No. animals/yr.	5	6	10
Steers per acre	1.5 - 2**	1.5 - 2	1.0
Final weight, lb.	966	988	998
Initial weight, lb.	459	459	450
Gain per steer, lb.	507	529	548
Daily gain per steer, lb.	1.63	1.70	1.76
Conc. int./hd./day, lb.	7.10	8.18	6.87
Conc. int./lb. gain, lb.	4.36	4.81	3.90
Carcass grade			
Choice	2	4	9
Good	8	8	11
Yield grade	2.20	2.60	2.80
Percent Choice	20%	33.3%	45%

*The steers in Lot 2 were fed at the 8-lb. level for 222 days and at the 11.5-lb. level per head daily for the last 90 days of the trial.

**Pastures were stocked at the rate of 1.5 steers per acre for the first 222 days and 2 steers per acre during the last 90 days.

considerably higher than Lot 3 in beef produced per acre. However, the intent was to stock the pastures based on the available forage in each lot, thus allowing a comparison of feed levels rather than stocking rate. It is recognized that there may have been variations in forage production and quality which could account for some of the differences in rate of gain and feed efficiency.

Steers fed at 1 percent of their body weight per day graded higher when slaughtered. The percentage of Choice carcasses produced in Lots 1, 2, and 3 was 20.0, 33.3, and 45.0 percent, respectively. This substantiates the earlier statement that cattle fed at 1 percent of their body weight tended to fatten earlier and carry a higher degree of finish throughout the feeding period. The same trend in fattening was exhibited with an increase in yield grade as the quality grade increased.

Carcasses produced in this program were highly acceptable. They were muscular and exhibited adequate marbling to grade Good to Choice. Backfat was thin, resulting in only a slight waste to the packer. The carcass fat was also highly acceptable in color, even though the steers had been fed on grass until slaughter.

Program No. 2—Deferred Feeding on Pastures

Procedure

Steers in Lots 1 and 2 were grazed together on winter and spring pasture (fescue or ryegrass alternately) without supplemental grain from October until May (217 days). In May of each year the cattle were randomly divided into two groups of eight animals each. The cattle were placed on common Bermudagrass pastures and fed supplemental concentrates for 128 days. Lot 1 received a 12 percent protein fattener pellet at the rate of 1.5 pounds per 100 pounds of body weight; Lot 2 was fed a mixture of equal parts of 12 percent protein pellets and hominy at the same rate. Pastures were stocked at the rate of two steers per acre.

Results and Discussion

The steers gained 1.15 pounds per day during the initial 217-day grazing period. There were no significant differences in performance between the two groups during the 128 days they were fed concentrates on pasture (Table 4). The cattle gained an average of 1.82 pounds per head per day with an average conversion rate of 6.25 pounds of concentrates per pound of gain.

Two-year slaughter data showed no observable differences between treatments. Both treatments were effective in producing desirable slaughter animals weighing approximately 900 pounds. These steers were not as heavy and the carcasses did not exhibit as high quality as those in Program 1. There was adequate marbling for most of the carcasses to grade Good to Choice (13 Good and Choice and 3 Standards in each treatment).

TABLE 4.—Three-Year Average Results of Summer Feeding on Grass (May–September; 128 days)

Treatment	1.5 lb. 12% protein pellets per 100 lb. body weight	1.5 lb. pellets and hominy per 100 lb. body weight
Lot No.	1	2
Steers per acre	2	2
Final weight, lb.	919	906
Initial weight, lb.	685	674
Gain per steer, lb.	234	232
Daily gain per steer, lb.	1.83	1.81
Conc. int./hd./day, lb.	11.52	11.21
Conc. int./lb. gain, lb.	6.30	6.19

Program No. 3—Deferred Feeding in Drylot

Procedure

Thirty-four fall-purchased calves were grazed on winter and summer pastures with no supplemental grain for 330 to 340 days and finished in drylot during an additional 112 days. The winter pastures consisted of fescuegrass and ryegrass. The ryegrass in the winter program was overseeded on common Bermudagrass at the rate of 20 pounds per acre in October or November. Lindsey 77F (forage sorghum) was planted on a prepared seedbed in May to provide summer grazing.

Results and Discussion

Winter and spring grazing for an average of 221 days (October 16 to May 24) increased weight from 424 to 696 pounds, or an average daily gain of 1.23 pounds. Summer grazing on Lindsey 77F produced final weights of 804 pounds and average daily gains of 0.96 pound per steer.

During the 112-day drylot finishing period, which extended from September 15 through January 3, the steers gained 249 pounds for an average daily gain of 2.2 pounds. The roughage intake was 5.28 pounds per head per day, or 2.36 pounds per pound of gain. The concentrate intake was 16.56 pounds per head per day, or 7.39 pounds per pound of gain.

The steers dressed 59.25 percent at slaughter. Carcass grades for the 34 animals were 10 Choice and 24 Good. The average yield grade was 2.58, indicating better than 50 percent lean cuts.

Data from this study suggests the importance of feeding grain in addition to pasture. These cattle were grazed almost as long as those in the previous programs but were not ready for slaughter until after a short drylot feeding period.

General Discussion

Previous work at the Northeast Louisiana Experiment Station and the Macon Ridge Branch Station has indicated that weanling calves may be held economically for on-the-farm feeding until ready for slaughter. This approach to feeding beef cattle is becoming more apparent with the tremendous increases in land prices and cost of maintaining a cow during the year. Therefore, the previously described programs involving a combination of pasture and grain feeding were investigated as methods that may be feasible to the producer for feeding cattle to an acceptable slaughter weight and grade.

Program 1 appears to have several advantages over the other two. On the basis of weight at slaughter, average daily gain, number of carcasses grading Choice, feed efficiency, and time required to finish the steers, the first program is superior. Cattle in Program 1 were slaughtered at approximately 950 to 1,000 pounds, which gives a desirable carcass weight of 550 to 650 pounds. Cattle in Program 2 were considerably lighter (906 to 919 pounds) at slaughter, while those in the last program weighed approximately 1,050 pounds at slaughter. Cattle in Program 1 were slaughtered at 312 days while those in Programs 2 and 3 were slaughtered after grazing and/or feeding periods of 345 and 447 days, respectively. The cattle in Program 3 could probably have been fed for a shorter period since they were heavier at slaughter than normally desired by most packers. This would have reduced the concentrates consumed by these cattle and probably increased the return since cattle become less efficient at heavier weights.

The average daily gains for combined treatments within the various programs were 1.70, 1.40, and 1.39 pounds for Programs 1, 2, and 3, respectively. These figures include both the grazing and/or drylot periods for the various programs. It was evident that steers fed concentrates at the beginning of the experiment were more efficient in their utilization than when fed in the latter stages. This was probably due to the fact that younger cattle are more efficient users of grain and heavier cattle decrease in their feed efficiency as they increase in weight.

It was of interest to note differences in concentrates consumed by cattle in the various programs. The most concentrates were consumed in Program 1 and the least in Program 2. However, the important consideration is not the total pounds of concentrates fed, but the quantity of total digestible nutrients (TDN) consumed. Unfortunately this could not be determined, since the quantity of forage consumed by the animals was not known. However, available data showing the amount of TDN required per pound of gain by beef steers would indicate that when less concentrates were fed in a treatment, more efficient utilization of forage was obtained.

Consumer preference for Good to Choice beef almost requires that cattle be fed some grain during grazing periods in order to produce carcasses containing sufficient marbling and quality to meet these grade standards. All three programs were effective in producing a majority of Good to Choice carcasses. Almost all carcasses were acceptable to the packer from the standpoint of fat color and degree of finish. Even though the cattle in Programs 1 and 2 grazed grass until slaughter, the fat was white and was not objectionable to the packer. An acceptable fat thickness over the ribeye was noted in all three programs.

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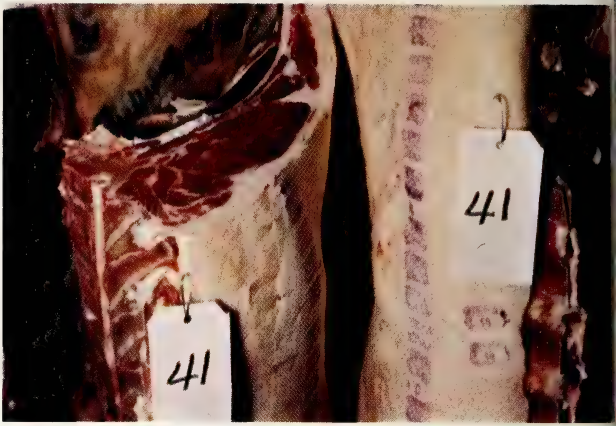
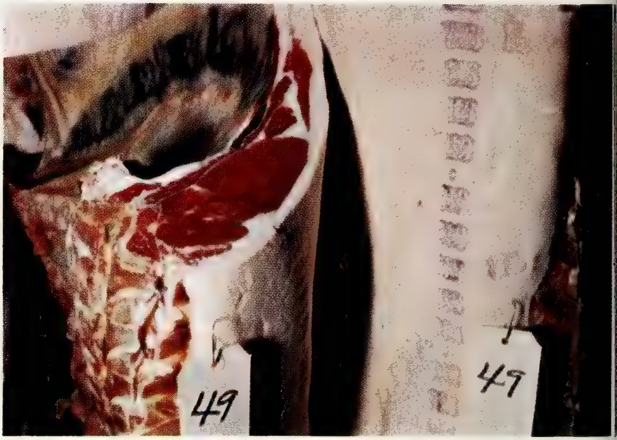
Rib Sections From The Three Programs



PROGRAM NO. 1 —
Superior marbling and a fairly thin rind fat.



PROGRAM NO. 2 —
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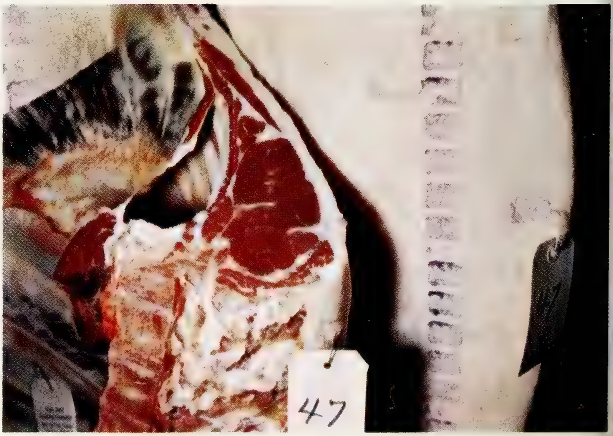

PROGRAM NO. 3 —
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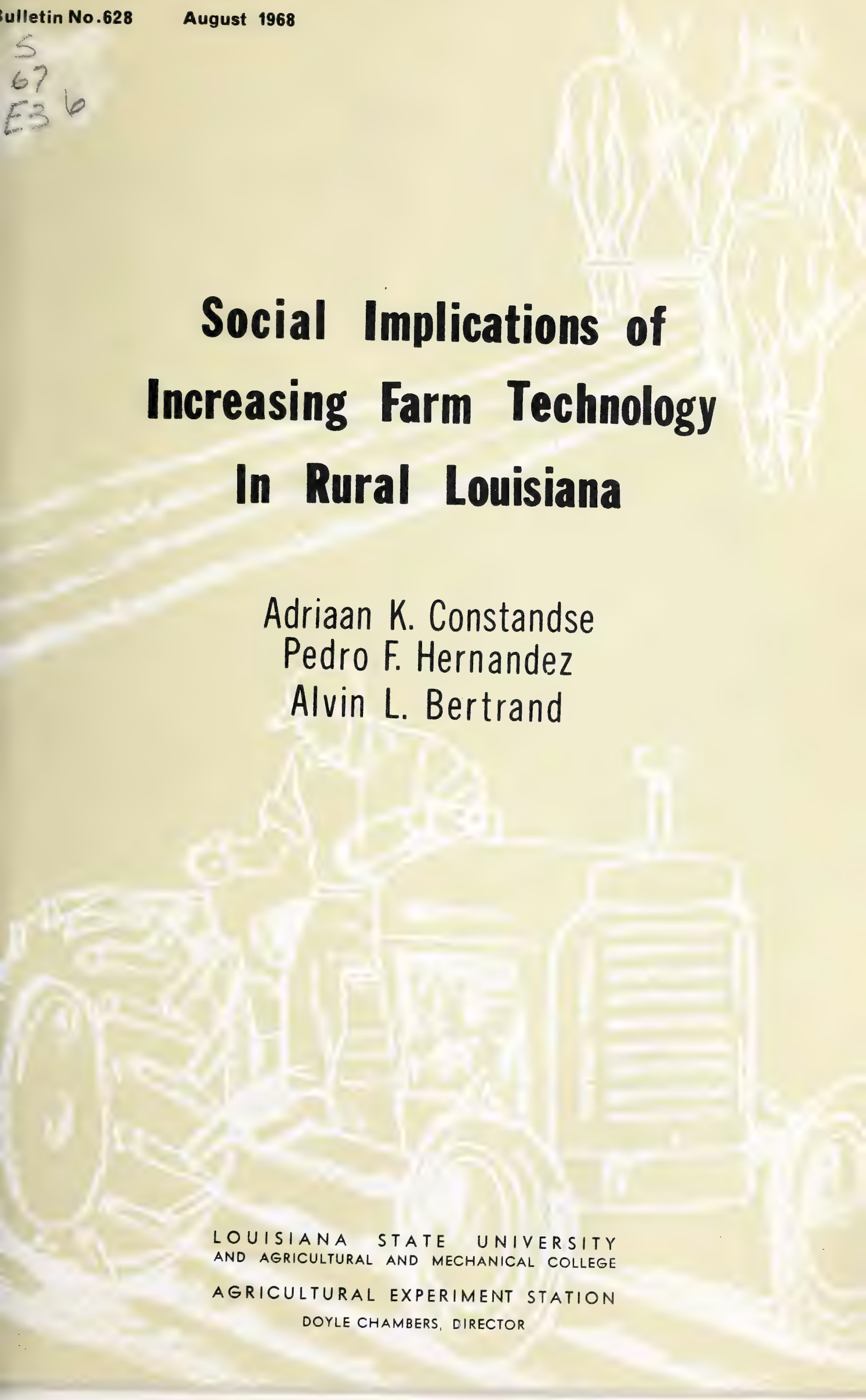

Social Implications of Increasing Farm Technology In Rural Louisiana

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Preface

This study on rural social change is another in the series began by the Department of Rural Sociology at Louisiana State University a quarter-century ago. The series is devoted primarily to keeping up with the impact of technology on farming and rural life. This research is a cooperative endeavor with the U.S. Department of Agriculture, accomplished under Regional Research Project S-61. It is related to the regional research program objective of studies of human resource development.

The fact that similar studies are being conducted in several states and nine European countries gives this report special significance. In each of these study areas essentially the same type of data will be collected in an effort to obtain information which will lend itself to comparative study.

The notion of an international cooperative research effort was first brought up at the meeting of the FAO (Food and Agriculture Organization of the United Nations) Working Party on Rural Sociological Problems in Europe held in Paris in August 1964. At that time a resolution was passed asking that the European Society for Rural Sociology direct the research on the social implications of mechanization on agriculture in Europe, which was jointly sponsored by FAO and the United Nations Educational, Scientific, and Cultural Organization (UNESCO). This resolution was accepted and working agreements drafted at subsequent meetings of researchers held in the Federal Republic of Germany, in the Netherlands, in Yugoslavia, in Ireland, and in Czechoslovakia.

The chairman of the group appointed to work out details of the European project was Dr. A. K. Constandse of the Netherlands. Since Dr. Constandse had served as visiting professor at L.S.U. in 1965, he was acquainted with work along this line which had been done by Dr. Alvin L. Bertrand in Louisiana. He invited Prof. Bertrand, and Dr. Paul Jehlik of the USDA, to meet with the European group in Dublin in August 1966. Out of this meeting came the idea that certain studies being planned in the United States could be collated with the European studies already begun. As it turned out, Dr. Constandse was invited to serve as visiting research professor at L.S.U. during the summer of 1967. During this time he supervised field work on the present project.

In the meantime, sociologists from a number of states had heard about the research. Several of them expressed interest in doing similar studies in their states and suggested a meeting. Preliminary conferences were held in connection with the annual Rural Sociological Society meeting in San Francisco in the summer of 1967 and the Development Committee meeting of the Rural Sociological Society in November of 1967. At the latter meeting plans were drawn for cooperation on a project to involve as many states as might be interested.

At present, studies are being planned or done in New York, Iowa, California, and Pennsylvania, as well as Louisiana. There is a possibility that other states will join this group.

This is the first time an attempt has been made to obtain data from such a large number of nations. Although there no doubt will be many problems to overcome, rural sociologists will have made their first attempt to systematically compare the rate and impact of change in different parts of the world.

Acknowledgments

Thanks are due to several persons who gave their help in some way or another in connection with this study, and especially to these persons associated with the Louisiana Cooperative Extension Service: Dr. J. H. Jones, Jr., and the County Agents of parishes where the research was carried out—Mr. C. J. Arceneaux, Lafourche Parish; Mr. Minus J. Granger, St. Mary; Mr. S. P. Firmin, Acadia; Mr. Roy D. Mitchell, Tangipahoa, and Mr. Max McDonald, Madison.

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Social Implications of Increasing Farm Technology in Rural Louisiana

Adriaan K. Constandse, Pedro F. Hernandez
and Alvin L. Bertrand*

Introduction

In every country, farmers are faced with the necessity of adjusting to an ever-increasing technology. The social and economic trends resulting from these adjustments have been similar, although the rate and specific manifestations of change have varied from nation to nation. Planners for national growth and welfare have concerned themselves with these developments. In the United States, three trends have received special attention: the continuing decrease in number of farms and increase in farm size; the movement toward "factories in the fields," including use of the accompanying techniques and practices of other industries; and the trend for capital investment and certain management decisions to be supplied by persons other than the farmer himself. These and related trends have been studied under the general heading of horizontal and vertical integration of agriculture. They have been shown to have important implications for rural life. Among other things, writers have noted that the farmer must give up part of his independence as farming takes on the character of business and industry, and as the farmer's occupational and family life tend to become distinct rather than common spheres of interaction for him. The conclusion usually drawn by observers is that the so-called family farm will completely disappear from the scene at some early point in time.

The above discussion sets the stage for the study reported here. The over-all purpose was to determine the impact of the trends noted above on farming and rural life in Louisiana and the United States. More specifically, information was sought on the reactions of farmers and their feelings about the future.

The study was undertaken as a contribution to the national and international project outlined in the preface. Hopefully, at the completion of the project, a fund of information will be available regarding the differential impact of technology in various regional and national settings. In addition some indication of the future of rural social life in different parts of the nation and Europe should be obtained.

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Objectives and Hypotheses

The over-all purpose of this study was to determine the continuing impact of technology on social change in rural areas. In more specific terms, the following objectives were in mind. The first objective was to determine the changes which occurred on Louisiana farms in the past two decades. The importance of this type of information is self-evident. Planners and policy makers need to know something about current trends if they are to plan intelligently.

The second major objective was to discover, insofar as possible, the reasons for changes which are taking place. There is very little information available as to why farmers are taking one course of action instead of another in the face of increasing technology. Also, not much is known about the way they feel about the changes taking place. These questions are significant to future production of food and fiber.

A third specific objective was to determine the impact of changes upon rural social organization; that is, the structure and functioning of the major social institutions in rural areas. These institutions will normally include the family, the church, local government, education, and the economy. Each of these social institutions is known to be changing rapidly and to have profound effect upon social life generally. However, the specific nature of the changes has not been carefully assessed.

The above stated objectives find their pertinence in the trends which have already been pointed out. However, they also have implications for what might be termed the derivative problems of change. These problems have been conjectured by many writers and observers of the current scene and take two general directions. First, it is acknowledged that mechanization or technology offers a means for the farmer to improve his condition; that is, to have higher productivity and more leisure time and income. However, at the same time it is pointed out that the *necessity* to mechanize causes him to face difficult problems which he may or may not be prepared to handle. If he is not prepared to handle these problems, then he is obliged to integrate his operation, which means going to someone on the outside for help with capital or management decisions, etc. It can be hypothesized that this process, while solving the immediate problems associated with mechanization, results in a loss of independent decision making. What it will mean in the long run is debatable, but it has serious implications for agriculture and rural life which cannot be overlooked.

The second derivative problem is associated with the first and may be stated in this manner: because of the obvious fact that they will lose some of their independence in the process, it can be hypothesized that some farmers will, at some point, cease to adopt technological developments. The problem here is to provide alternatives for the farmer which are acceptable and which will not slow down increasing efficiency of productivity. This problem has not been given serious research attention, but cannot be overlooked too much longer. In other words, it must be determined if there are better and more attractive alternatives than vertical integration in agriculture.

The above objectives and hypotheses provided the broad outline for this study.

Basic Assumptions

The reader will more fully understand the approach of the study if he is aware of certain assumptions which were made. These assumptions serve to explain why certain methodological decisions were made and why certain procedures were followed.

The first assumption of the study was that technology was related to or associated with rural social change including all the socioeconomic and sociocultural trends which could be identified. In this regard, technology was defined in its broadest sense to include not only the introduction of machinery and equipment but also the application of any type of new methods in farming. It was construed to include advantages in transportation, processing, and marketing as well as in production. With regards to the above assumption, it was accepted that the exact contribution which an item of technology might make to change could not be assessed with existing data and techniques. Nevertheless, it was assumed it was possible to gain some insight into the relationship between technology in general and change.

The second assumption was that technology would not develop evenly and that it would differ from one type farming region to another within the state and within the nation, as well as between nations. In this regard, technology is a function of such factors as agricultural policy, local value systems, degree of industrialization, and many other factors. With this thought in mind, it was considered desirable and feasible to study the reasons why technology did not move at the same rate in all areas of the state. It was assumed that this study would provide some clues to general principles relating to technological advancement.

The third assumption was that agriculture and rural life will remain an important over-all concern in the state, in the nation, and internationally for the foreseeable future. This is not to say that there will not be changes, but that it is most important to continually study this segment of the population.

The Study Setting

A brief review of some facts about Louisiana will set the stage for the study report. First, the state is not an extremely large one but it is larger than quite a few European countries. It includes some 48,500 square miles, or approximately 31 million acres, within its borders. For the most part the terrain is quite level. There are no mountain ranges within the state and the highest elevation is approximately 500 feet above sea level. Average elevation is about 30 feet above sea level.

Soils of the state vary from the rich, fertile soils of the Mississippi, Red, and Ouachita rivers, which have a high plant nutrition level, to the poor soils in the northern and western hill sections of the state. The latter have very little natural fertility. Historically, a rather large portion of the state was subject to flooding as might be deduced from its elevation. However, within recent years increasing control of waters has been attained through drainage projects. In this regard, much of the soil in the southwestern and southern parts of the state has an impervious clay sub-soil which is ideal for the cultivation of rice and other enterprises such as the growing of fish and crawfish. Coastal areas remain largely out of agriculture but are used for many agriculturally-related activities such as fishing and trapping.

Louisiana's climate is semitropical, and it has one of the highest annual rates of rainfall in all of the United States. Rainfall varies from 46 inches annually in the northwestern part of the state to 56 inches in the southern part. The growing season is quite long, ranging from 220 days in the north to 320 days in the extreme southeast section of the state.

The 1960 census classified approximately two out of five Louisianians as living in rural areas. Today it would be more correct to say that approximately one out of three Louisianians is a ruralite. The state is industrializing rapidly with an increasing number of petrochemical plants figuring in the industrial growth. Three major ports are also located in the state, and account for much business and commercial activity.

Louisiana's soils and climate account for its great diversity of agriculture. This diversity is shown in a recent classification worked up by Leo Polopolus.[1] He delineated 11 areas which could be set apart on the basis of agricultural production. These are:

1. A and B Upland Louisiana Timber Area and Northwest Louisiana Hill Area (timber, peaches, broilers are the most important cash products).
2. North Central Louisiana Cutover Pine Area (timber).
3. Red River Cotton Area (cotton, pecans, hay, cattle and calves).
4. Cutover Flatwoods Area (sheep and lambs, cattle and calves).
5. Mississippi Delta Area (cotton, soybeans, cattle and calves, oats, corn).
6. Central Louisiana Mixed Farming Area (cotton, sweet potatoes, corn, hogs, pigs).
7. Louisiana Rice Area (rice, cattle and calves).
8. Louisiana Sugar Cane Area (sugar cane for syrup, sugar cane for

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[1] Leo P. Polopolus, *Louisiana Agriculture, Economic Trends and Current Status* (Baton Rouge; La. Agricultural Experiment Station Bulletin No. 550, 1962) p. 63. Note: There is a remarkable correlation between the areas delineated by Polopolus and the rural social areas delineated by Bertrand in *The Many Louisianas* (Baton Rouge: La. Agricultural Experiment Station Bulletin No. 496, 1955).

sugar, Irish potatoes, commercial vegetables).

9. Southeast Mixed Farming Area (cattle and calves).

10. Louisiana Dairy, Poultry, and Truck Area (milk, cows, strawberries, Tung nuts, eggs, chickens, broilers, greenhouse and nursery, timber).

11. New Orleans Truck and Fruit Area (oranges, greenhouse and nursery).

Diversity in productivity and in farming enterprises within the state is, of course, related to differences in farm size and productivity in cash income, and consequently to differences in general cultural characteristics. These facts should be kept in mind as the changes which have taken place within the past 20 years are reviewed.

General Features of the Changing Rural Scene

Some 17 years ago, one of the authors of this report studied the implications of farm mechanization in Louisiana.[2] In his report he concluded, among other things, that agricultural mechanization had been stimulated by factors which served to pull laborers off the farm (industrial employment) and to push them off the farm (mechanization). The motives in each case were economic, although in the first instance they were invested in the laborers and in the second instance in the farm operators. Several specific changes on farms and in the farm population were related to increasing mechanization at the time. The over-all finding was that the major social trends, together with technological advances and changes in ideologies and philosophies, had worked to reduce the differences between the two major residential segments of the population—rural and urban. This study served as the first bench mark for the evaluation and understanding of the changing rural scene in Louisiana. The data which are presented in the first section of this report are designed to give a second bench mark, some 20 years later.

Methodologies and procedures used are quite simple. Census data are used to show trends and changes over the past 20 years, 1944-64. These data are presented in terms of indexes or averages and are treated in a descriptive manner.

Numbers of Tractors and Trucks

The number of tractors on farms continued to increase during the past 20 years. However, with the advent of many types of self-propelled machines, tractors are not as precise an index of mechanization as they once were. There is also much greater variation in the size and power of tractors now than there was in years past. Nevertheless, it is possible to obtain a general picture of technological change by plotting trends in the number of tractors on farms. This has been done for Louisiana from

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[2] Alvin L. Bertrand, *Agricultural Mechanization and Social Change in Rural Louisiana* (Baton Rouge: La. Agricultural Experiment Station Bulletin No. 458, 1951).

TABLE 1.–Changes in Numbers of Tractors and Trucks in Louisiana, 1944-64

Census year	Tractors		Trucks	
	Number	% increase	Number	% increase
1944	17,630		18,637	
1949	35,735	102.7	20,974	12.5
1954	51,929	45.3	36,824	75.6
1959	55,808	7.5	47,153	28.0
1964	60,626	8.6	51,295	8.8

Source: U.S. Census of Agriculture, 1945-64.

1944 to 1964 in Table 1. This table shows that the number of tractors increased by some 22,000 between 1944 and 1954, or approximately 3,000 per year. Since then the growth rate has declined to about 1,000 per year, but is still significant in light of the fact that there are over 60,000 tractors already in the state. The relationship of tractors to mechanization and to changes in farming will be discussed in more detail in connection with the analysis of data obtained through personal interviews.

The number of trucks on farms also continues to increase. This is another item of equipment which can be related closely to increasing technology. The fact that the number of such vehicles on farms in the state more than doubled in 20 years is indicative of the rate of change. In 1944 there were 18,637 trucks on all farms in the state. This number had increased to 39,691 in 1964. One can easily imagine the change in transportation practices associated with this increase. In turn, farm management practices are certain to have been affected.

Numbers of Livestock and Poultry

There is no doubt of a relationship between increasing technology and changes in patterns of livestock and poultry production. This relationship may be seen as quite direct when machines reduce or eliminate the need for certain draft animals. In Louisiana and the U.S. the number of horses and mules on farms has become so small that it was not reported in 1964. By contrast, in 1944 farmers reported owning 67,353 mules and mule colts and 64,435 horses and colts. The ramifications of this change are dramatic in the sense that the passing of an era is heralded.

Livestock other than draft animals are also affected by technology. For this reason data were worked up to show the changes in average numbers of cattle and calves, hogs and pigs, sheep and lambs, and chickens on Louisiana farms in 20 years. Interestingly, according to census data, almost all Louisiana farmers have increased their herds of cattle (Table 2). The average number of cattle and calves on farms almost tripled in the last 20 years, jumping from 11.4 in 1944 to 29.9 in 1964. This indicates a clear change in the practices of farmers.

TABLE 2.–Changes in Numbers of Selected Livestock and Chickens on Louisiana Farms, 1944-64

Census year	Average number per farm			
	Cattle & calves	Hogs & pigs	Sheep & lambs	Chickens
1944	11.4	6.2	1.3	38.6
1964	29.9	2.9	0.6	61.9

Source: U.S. Census of Agriculture, 1945 and 1964.

In contrast to cattle, sheep and hogs have declined in Louisiana. The average number of hogs and pigs on farms was 6.2 in 1944. By 1964 the average had dropped to 2.9. Sheep and lambs averaged 1.3 in number on farms in 1944, but were down to an average of 0.6 in 1964. This trend also is of significance. It demonstrates that farmers are not motivated to raise these animals.

The number of chickens per farm increased by one-third in 20 years, probably reflecting a regional trend in this direction. Today the average Louisiana farmer has something like 62 chickens on his farm. There is no doubt that technology is related to this increase in production. Recent discoveries have not only substantially decreased the cost of poultry enterprises, but have led to entirely new types of tenure relations. The latter fall under the rubric of contract farming and integration in agriculture and have implications for the whole value orientation of rural persons.

The question of why pork and sheep enterprises have not caught the fancy of Louisiana farmers is an interesting one. This is especially true since the state does not produce enough meat of these types for home consumption. It is apparent that a syndrome of economic and social factors is operative to reinforce negative attitudes toward these enterprises. Study of what makes cattle and poultry more attractive than pork and sheep might be worthwhile in terms of future programs of education.

Tenure Patterns

The relation of man to land is a vital aspect of the social organization of rural areas. For this reason it was considered worthwhile to investigate changes in tenure patterns in the state within the past two decades. According to census tabulations, the number of owner-operated farms decreased by one-third (36.3 per cent) during this period (Table 3). This trend is part of an evolving rural scene which includes fewer farms. However, it does not imply that the percentage of owners is decreasing.

One of the most significant aspects of changing tenure patterns is the drastic drop in the number of farms using laborers in 20 years. Just one Louisiana farm uses hired laborers today where two used laborers in 1944. This sort of statistic brings home most forcibly the impact of

TABLE 3.–Changes in Numbers of Owner-Operated Farms and in Numbers of Farms Using Laborers, Louisiana, 1944-64

Census year	Number of owner-operated farms	Number of farms with laborers
1944	58,761	42,024
1964	37,439	24,064
Per cent change	36.3	42.7

Source: U.S. Census of Agriculture, 1945 and 1964.

TABLE 4.–Changes in Selected Tenure Groups, Louisiana, 1944-64

Census year	Per cent each tenure group is of all tenures			
	Full owners	Part owners	Manager	All others
1944	45.4	5.0	0.4	49.1
1964	59.9	20.2	0.4	19.5

Source: U.S. Census of Agriculture, 1945 and 1964.

mechanization and of other aspects of technology. It also helps to explain the plight of cities, which have had to absorb the laborers no longer needed on farms when machines are introduced.

In 1944, over 45 per cent of the farmers in the state owned all the land they worked and another 5 per cent owned part of their farms. Twenty years later, 60 per cent of all Louisiana farmers owned all their land and another one-fifth owned part of their land. This is a tremendous increase in this tenure class. In fact, as can be seen in Table 4, renters and other non-owners dropped from about half of all farmers in 1944 to only 20 per cent in 1964.

The change in the tenure picture over the state in the past 20 years opens the door to considerable speculation. In the first place, one wonders how direct the impact of technology has been in bringing about this development. In the second place, it indicates that farming will soon be basically an owner-operator type of venture. What this means in terms of the traditional types of tenure problems is questionable.

Number and Size of Farms

It has been mentioned that the size of farms has been increasing in the state for well over a quarter century. In 1944 the average farm included only 77.6 acres. By 1964 it had grown to 166.7 acres. In other words, the average size of a farm more than doubled in 20 years. Table 5 was prepared to show this change in its most dramatic form; i.e., by varying size-of-farm classes. It can be seen that farms of less than 50 acres are disappearing at a fast pace. Whereas there were close to 110,000 of these farms in 1944, there were only 32,000 remaining in 1964. By contrast, the larger farms, or those ranging in size from 250 acres upwards, increased in number rather sharply. Where there were only 122 farms in the state ranging from 1,000 to 1,999 acres in 1944, there were

TABLE 5.–Changes in Farms by Size, Louisiana, 1944-64

Size of farm	Number of farms 1944	 1964
Less than 10 acres	26,295	4,807
10-49 acres	82,359	27,083
50-99 acres	5,470	11,864
100-139 acres	6,569	4,743
140-179 acres	3,831	2,985
180-219 acres	2,050	1,967
220-259 acres	1,206	1,334
260-499 acres	3,166	3,752
500-999 acres	1,531	2,275
1,000 acres or more	122	1,657

Source: U.S. Census of Agriculture, 1945 and 1964.

1,059 farms of this size in 1964. Farms of 2,000 acres or more increased from none to 598 in this same period.

It is most interesting to note that the number of farms in the state dropped drastically, from 123,000 in 1944 to 62,466 in 1964, a decrease of over 49 per cent. Said another way, there are only half as many farms today as 20 years ago.

Again, the causal effect of increasing technology is readily apparent. Here, one must not only imagine larger and larger machines operating on ever-expanding holdings, but also must consider emerging patterns of life entirely different from those of the past. People on farms averaging over 250 acres will not be in as advantageous a position for intimate and close relationships with neighbors as people who live on 40-acre farms. Some of the patterns and consequences of these changes will be brought out in the last section of this report.

Land-Use Patterns

Table 6 shows the gross changes in land-use patterns on farms from 1944 to 1964. The first trend which is obvious is the decrease in total acreage of cropland and in cropland harvested. In the last two decades, cropland acreage on farms has decreased by over a million acres, and the acres in harvested cropland has decreased almost as much. The percentage of Louisiana farm acreage in cropland is now only 36.1 per cent. It was 41.9 per cent in 1944. These trends have been accompanied by a doubling of the farm acreage devoted to woodlands (an increase from 1.5 million acres to 3 million acres). A much larger percentage (10.3 per cent) of woodland was pastured in 1964 than in 1944.

The above trends are more or less a direct result of technology. As production efficiency increases, fewer acres of cropland are needed to produce the required food and fiber. Perhaps the untold drama of the above trends is the number of farmers who have left farming, the number of farms which have become idle or consolidated with other farms, and the general shift of rural life from a rural type of organization to an urbanized type of organization.

Farms by Economic Class

One of the best ways to measure the impact of change in agriculture is to plot trends in the number of various size commercial farms. This has been done in Table 7. This table shows that agriculture in Louisiana has become a great deal more commercialized in nature in the past 20 years. This is evident despite the fact that the total number of commercial farms has decreased drastically. What has happened is that Class I farms (sales of $40,000 or more), Class II farms (sales of $20,000 to $39,999), and Class III farms (sales of $10,000 to $19,999) have increased markedly. By contrast, the number of Class V farms (sales of

TABLE 6.–Changes in Land-Use Patterns on Louisiana Farms, 1944-64

Land use	Acreages on farms 1944	Acreages on farms 1964
Cropland	4,103,007	2,968,207
Harvested	3,490,159	2,672,632
Idle	612,848	295,575
Pastureland	3,920,572	N/A[1]
Plowable	1,502,337	N/A[1]
Woodland	N/A[1]	1,719,026
Other	N/A[1]	2,003,709
Woodland	1,519,358	2,966,160
Pastured	25,352	1,719,026
Not pastured	1,494,006	1,247,134

[1] Not available.
Source: U.S. Census of Agriculture, 1945 and 1964.

TABLE 7.–Changes in Farms by Economic Class, Louisiana, 1944-64

Economic class	Numbers of farms 1944	Numbers of farms 1964
Commercial farms	129,209	32,814
Class I (sales of $40,000 or more)	285	2,266
Class II (sales of $20,000-$39,999)	572	2,976
Class III (sales of $10,000-$19,999)	1,489	3,845
Class IV (sales of $5,000-$9,999)	3,176	4,403
Class V (sales of $2,500-$4,999)	8,897	6,168
Class IV (sales of $50-$2,499)	114,790*	13,156
Other farms	0**	29,652

Source: U.S. Census of Agriculture, 1945 and 1964.
*For 1944 all farms from 0 sales to $2,499 included in this class.
**In 1944 part-time and part-retirement farms not listed separately.

$2,500 to $4,999) and of Class VI farms (sales of $50 to $2,499) decreased sharply. Comparable data for 1944 are not available for "other" farms; that is, part-time and part-retirement farms.

The above trends indicate that factory type production is moving into Louisiana fields. In order to achieve the sales volume necessary for a large commercial farm to be profitable, it must be run as any other business. This is the new outlook and the new image of agriculture.

Value of Products Sold, Levels of Living

The value of products sold on a farm gives some indication of the level of living of the farm family in that it relates to the ownership and/or use of a certain amount of equipment and facilities. In this regard, it is of interest that the average farm operator only sold or used $1,709 worth of farm products in 1944. By contrast, in 1964 farm operators averaged selling $6,513 of farm products (Table 8). This is indeed a drastic change, one which has implications for rural life.

Those items of technology which are generally used as indexes of level of living are widespread on Louisiana farms. In 1944, just over one-fourth of the farmers of the state (28.9 per cent) owned automobiles. Two decades later almost three-fourths (73.8 per cent) had an automobile available for the use of their families. Telephones moved into Louisiana farm homes at an even faster rate. In 1944 only 5 per cent of all farmers had a telephone in their homes. In 1964, almost seven of 10 (67.6 per cent) had access to this media of communication. By 1964, running water and electricity were so common on Louisiana farms that they were not even enumerated. However, two items not known in 1944 were counted—home freezers and television sets. It is another commentary on the rapid rate of change on Louisiana farms that 88 per cent were equipped with a T.V. set and 80 per cent with a freezer within the past 20 years.

Size and Composition of the Population

The changes in the population of the state during the last two decades indicate rapid growth. There were 2,364,000 people in Louisiana in 1940 and an estimated 3,700,000 in 1968. The rural-farm part of the

TABLE 8.–Changes in Value of Products Sold and Specified Level-of-Living Items on Louisiana Farms, 1944-64

Census year	Value of products sold by farm	Percentage of farms with:			
		Telephones	Automobiles	Home freezer	T.V.
1944	$1,709	5.0	28.9	0	0
1964	$6,513	67.6	73.8	80.0	88.0

Source: U.S. Census of Agriculture, 1945 and 1964.

TABLE 9.–Changes in Age Distribution of Rural-Farm Population in Louisiana, 1940-64

Census year	Per cent of population in each age group					
	Under 5	5-14	15-24	25-44	45-64	65 and over
1940	11.9	24.2	20.4	24.4	14.4	4.7
1964	7.1	23.0	14.9	18.8	27.6	8.6

Source: U.S. Census of Population, 1940, and U.S. Census of Agriculture, 1964.

population had undergone even more drastic change, dropping from approximately 600,000 persons in 1944 to something like 234,506 in 1964. This means that there are only about two rural-farm persons now where there were five 20 years ago.

Other changes in the rural-farm population have also taken place. First, as can be seen in Table 9, the rural-farm population has gotten considerably older in two decades. The per cent of the population in each of the age groups under 45 was less in 1964 than in 1940. By contrast, the per cent of the population in age groups above 45 was considerably larger.

A second change reflected in the composition of the rural-farm population is an increase in the relative number of women. In 1940, there were 107.1 males on farms for every 100 females living there. By 1964 this imbalance had all but been wiped out. The sex ratio had dropped to 101.3. It is not clear what brought about this reversal in trend. Perhaps farm life has become more attractive for females.

A final trend which affects the composition of the population needs to be called to attention. This trend affects the so-called quality of the population and relates to educational attainment. In 1940, only 3.6 per cent of the persons 25 years and over living in rural farm areas had completed high school. This picture is still not bright, but there is considerable implication for the future in the fact that by 1964, 14.6 per cent of those 25 years and over on farms had finished four years of high school.

Specific Features of the Changing Rural Scene

The findings reported in the preceding discussions, based on census information, were designed to show certain over-all changes in Louisiana agriculture over the past 20 years. While this type information is both interesting and useful, the writers did not feel it went far enough in showing specific changes and in providing insight relative to the changing rural scene. For these reasons it was decided to conduct interviews with farmers in representative areas of the state. The methodological procedure employed can be outlined as follows.

It was decided after consultation with knowledgeable persons from the Cooperative Extension Service and the Louisiana Agricultural Experiment Station to select four study areas representative of the main agricultural activities in Louisiana. These areas were essentially the same as the ones delineated for the study made 20 years ago, with one exception. The hill area of the northwestern part of the state was not sampled, because farming has become relatively unimportant there.

The areas selected were:

1. Lafourche and St. Mary parishes (main crop: sugar cane).
2. Acadia Parish (main crop: rice).
3. Tangipahoa Parish (important dairy region).
4. Madison Parish (main crop: cotton).

In each area a sample of 50 farmers was drawn from the list of farmers who produced the main crop of the area. These lists were provided by county agents.

Replacement names were drawn for farmers who had died, retired, left the area, or took other jobs. The interviews were conducted during July 1967. Refusals were rare; there were not more than five. In all areas farmers were found to have time to talk because it was the slack season just before the harvest period.

The average age of the interviewees was 52 years. However, in no less than 35 per cent of the interviewee families, there were no children. Approximately 4 per cent of the interviewees had no schooling at all. Twenty-nine per cent had 4 or less years of schooling. Over one-third (36.5 per cent) had 5 to 8 years of school; 11.5 per cent had 1 to 3 years of high school. One-tenth were high school graduates, another 4.5 per cent had some college, and the same percentage had earned a college degree.

The level of living of interviewees is indicated by the following facts. Four out of five of the houses in which interviewees lived were reported to be in good repair. Approximately 97 per cent had water piped into their houses and 94 per cent possessed a home freezer. Only 18 per cent had a dishwasher. But, 25 per cent owned a color T.V. Forty-four per cent of the respondents had two or more telephones in their houses or barns and nearly 100 per cent had at least one telephone. Eighty-nine per cent of the farmers had one or more family cars and 82 per cent also owned a pickup truck.

The data collected and presented here are arranged so that differences between areas are highlighted. In the discussions which follow, farmers interviewed from Lafourche and St. Mary parishes will be identified as from the sugar belt, those from Acadia Parish as from the rice area, those from Tangipahoa Parish as from the dairy area, and those from Madison Parish as from the cotton part of the state. These designations do not, of course, imply exclusiveness in these production enterprises. In this regard, soybeans and cattle are found widely spread throughout the state. Although the tables presented are more or less self-explanatory, brief comment is included to give the insights and hypotheses derived by the authors from their fields and other experiences. No involved statistical tests were used because of the nature of the data and the purposes of the study.

Operation of Farms

Each farm operator interviewed was asked how his farm was presently operated—whether he was the individual operator, whether he worked under a partnership agreement, or whether some other type of arrangement prevailed. Those who responded that the farm was worked under a partnership arrangement were asked if the partners were relatives. Each interviewee was also asked if the arrangement for operating the farm had changed since 1957. The types of farm operations which were reported are shown in Table 10. It can be seen that more than four out of every five farms in the sample groups were individually operated. Interestingly, 11 per cent of the farms were run by partners who were relatives and about 4 per cent by non-related partners. Other types of operations were represented by only 2 per cent of the farms visited. In this regard, an important observation can be made from information gleaned during the field work. Partnership with family very often means nothing more than a business arrangement between a father and a son. This is a formalization of an actual situation which exists in many other cases where a formal partnership agreement has not been drawn up. Apparently there is growing recognition that problems related to inheritance and transfer of ownership are minimized when formal working agreements are drawn up.

TABLE 10.–Types of Farm Operations Reported by Interviewees

Type farm operation	Lafourche, St. Mary	Acadia	Tangipahoa	Madison	Total sample
	Per cent	Per cent	Per cent	Per cent	Per cent
Individually operated	72.0	76.5	89.8	96.0	83.5
Partnership with family	16.0	15.7	10.2	4.0	11.0
Partnership with others	6.0	5.8	-	-	3.5
Other arrangements	2.0	-	-	-	0.5
Corporation	4.0	2.0	-	-	1.5
	100.0	100.0	100.0	100.0	100.0

Table 10 shows important differences in patterns of farm operation. A much higher percentage of farms in Madison and Tangipahoa parishes are individually operated than is true in Lafourche, St. Mary, and Acadia parishes. By contrast, in the sugar and rice areas one-fifth of the farms are partnership operations. This number is significantly higher than the number found in Tangipahoa (10 per cent) and Madison (4 per cent) parishes. Corporation farms, although small in number, seem to be a phenomenon limited to the sugar and rice areas.

The question regarding changes in types of operations during the past 10 years brought answers in line with the general trends outlined in the preceding section of this report. Approximately one out of four interviewees (27 per cent) said present operating arrangements differed from those they had 10 years ago. Two trends predominated. The first was for farmers to move from a tenant type arrangement to an individual operator arrangement. Some 18 per cent of the farmers interviewed made this shift. This trend did not show in the Madison Parish area, but was fairly evenly distributed in the other three areas. The second trend, toward partnership agreements, has already been noted. Some 7.5 per cent of the farmers indicated they had made a change of this type involving relatives, and the remainder (2.5 per cent) of those making this change had moved to partnership agreements with non-relatives.

Size of Farms

The first section of this report indicated changes in the sizes of farms over the state since 1944. In this regard, it was considered important to determine how much change in size the farms included in the sample had undergone in the past 10 years. Table 11 gives an idea of the size of sample farms in each sample area, while Table 12 shows the percentage of farms in each area remaining the same size or changing size in the last decade.

It may be surprising to some to discover the wide variation in farm sizes in each of the study areas. The Tangipahoa area was the only one in which no farm sampled exceeded a thousand acres. However, approximately one-fourth of the farms in this area exceeded 250 acres. Farms of 1,000 acres or more made up over one-tenth of all farms sampled. The rice area apparently has a larger percentage of farms over 150 acres than the other areas, while the cotton-culture area had the largest percentage of farms under 150 acres. One might expect more small farms in the dairy area. However, the move to bulk tank operation has eliminated most of the small dairy operators.

A general comment may be made in terms of the size of farms. Rather surprisingly, almost all farms in every parish surveyed were limited to one or at most two major enterprises. Thus they are, in one sense, highly specialized operations. This is one difference which stands out by comparison with European farms. Another is the wide range in size of farms. A third difference is the fact that most farms have substantial acreage not in cultivation.

Table 12 shows the types of changes which took place on farms since 1957. It can be seen that patterns of change vary as one moves from one part of the state to another. For example, in Madison Parish almost one-fifth of the farms were smaller than in 1957. However, 30 per cent of the farms sampled added more than 100 acres during this time. It is indicative of the rate of change in the dairy area that almost half

TABLE 11.–Size of Farms Included in Sample Groups

Size (acres)	Lafourche, St. Mary	Acadia	Tangipahoa	Madison	Total
	Per cent	Per cent	Per cent	Per cent	Per cent
10-30	18.0	2.0	0.0	8.0	7.0
30-50	0.0	5.9	4.1	14.0	6.0
50-100	20.0	7.8	12.2	22.0	15.5
100-150	14.0	2.0	30.6	8.0	13.5
150-250	14.0	23.5	28.5	12.0	19.0
250-500	16.0	21.6	20.4	16.0	18.5
500-1000	10.0	17.6	4.2	4.0	9.5
1,000 and over	8.0	19.6	0.0	16.0	11.0
	100.0	100.0	100.0	100.0	100.0

TABLE 12.–Changes in Size of Farms Included in Sample, 1957-67

Change	Lafourche, St. Mary	Acadia	Tangipahoa	Madison	Total
	Per cent	Per cent	Per cent	Per cent	Per cent
No change since 1957	64.0	60.8	53.1	42.0	55.0
Smaller than in 1957	6.0	5.9	4.1	18.0	8.5
Enlarged with 10 acres	6.0	2.0	2.0	-	2.5
Enlarged with 20 acres	2.0	2.0	2.0	6.0	3.0
Enlarged with 50 acres	12.0	5.9	4.1	4.0	6.5
Enlarged with 100 acres	-	5.9	10.2	8.0	6.0
Enlarged with 200 acres	2.0	3.9	20.4	2.0	7.0
Enlarged with 300 acres	2.0	-	2.0	4.0	2.0
Enlarged with more than 300 acres	6.0	13.6	2.1	16.0	9.5
	100.0	100.0	100.0	100.0	100.0

the farms in Tangipahoa changed size in the last 10 years. Over one-third (35 per cent)) of the farms sampled in this parish added at least 100 acres. The rate of change was not as great in the other three areas.

It is worth noting one impression gathered during the field work. This was that those farms which were becoming smaller were generally those on which older people remained. The pattern seems to be for the farm owner-operator to gradually sell or rent some of his land as he grows older. This pattern was especially pronounced in the dairy area of the state.

Land Tenure

Table 13 shows the types of tenure arrangements which were found on the farms studied. Precisely one-half of the interviewees owned all the land they operated and did not rent or lease additional acreage. Two patterns of ownership tenure emerge in the four study areas. In the dairy and cotton areas, ownership runs very high—70 per cent or more. In contrast, in the sugar and rice areas only about one-fourth of the respondents owned all the land they worked. In the latter areas, it seems the majority of farmers rent or lease a substantial part of the acreages they cultivate. Very few share tenants were reported (1.5 per cent), demonstrating that old "sharecropper" practices have almost, if not completely, disappeared. Inquiries made at the time of interviews indicate that buying land is almost out of the question in these two areas.

TABLE 13.–Tenure Status of Farmers in Sample Group

Tenure status	Lafourche, St. Mary	Acadia	Tangipahoa	Madison	Total
	Per cent	Per cent	Per cent	Per cent	Per cent
Owned:					
All land	22.0	25.5	81.7	70.0	50.0
More than 50%	6.0	13.7	8.2	14.0	10.5
Rented:					
More than 90%	46.0	29.4	0.0	4.0	20.0
51%-90%	14.0	29.4	8.1	12.0	16.0
Half and half	4.0	2.0	0.0	0.0	1.0
Share tenant	6.0	0.0	0.0	0.0	1.5
No answer	2.0	-	2.0	-	1.0
	100.0	100.0	100.0	100.0	100.0

TABLE 14.–Reported Ways Farmers in Sample Group Changed the Size of Their Farms, 1957-67

Type of change	Lafourche, St. Mary	Acadia	Tangipahoa	Madison	Total
	Per cent	Per cent	Per cent	Per cent	Per cent
No change	60.0	58.8	53.1	42.0	53.0
Increased by:					
Buying	4.0	5.9	26.5	24.0	15.0
Renting	30.0	23.5	8.2	14.0	19.0
Inheritance	0.0	3.9	4.1	2.0	2.5
Partnership arrangement	0.0	0.0	4.1	0.0	1.1
Decreased by:					
Selling	0.0	0.0	2.0	8.0	2.5
Renting	4.0	2.0	2.0	8.0	4.0
Other	2.0	3.9	0.0	0.0	1.9
Not cultivating	0.0	2.0	0.0	2.0	1.0
	100.0	100.0	100.0	100.0	100.0

The possibility of oil or natural gas being found causes owners to hang onto land, whether or not they are able to farm it. This factor did not appear to be as important in the other two study areas of the state. In this regard, much of the land in Madison Parish was obtained by drainage and clearance of hitherto sub-marginal land.

It was considered worthwhile to learn how the farmers who had changed their acreage had gone about doing so. Of approximately half of the interviewees who had made a change, 15 per cent had increased their size of operation by buying more land, and 19 per cent had grown larger by renting from others. A few (6.5 per cent) had grown smaller from selling or renting. Most of the renting took place in the sugar and rice areas. The details of size changes are shown in Table 14.

Buildings, Facilities, and Improvement of Land

Each farmer interviewed was asked if he had made any changes (including renovation or construction) in his permanent farm buildings during the past 10 years. In addition he was queried on whether or not equipment or other facilities of a permanent nature (such as a milking machine or an irrigation or electrical system) had been added to his farm during this period. A discovery made during the field work invalidated the question relative to farm buildings to a considerable extent. At least two hurricanes had swept over most of the state during the 10-year period under study. Almost all farmers had suffered enough damage to their buildings to warrant repair if not complete reconstruction, as is shown by the fact that only 2 per cent of them did not repair their buildings in some way. There was no way of knowing what repairs would have been made otherwise.

The dairy area was the only area where an unusually high percentage of farmers made changes in facilities. This fact is easily associated with the new milk sanitation regulations and new milk marketing procedures inaugurated during recent years. As many as three-fourths of the farmers in Tangipahoa reported adding either a bulk milk tank or a milk pipeline or both. A considerable number of farmers in the rice area—11.8 per cent of those interviewed—had had irrigation wells dug and equipped in the last 10 years. Other changes mentioned were the building of silos and installation of irrigation systems, but most farmers (71 per cent) did not add any type of facility.

Two practices rather common in Louisiana tended to arouse the interest of the co-researcher from Europe. The first practice was that of leaving machinery and equipment, even expensive harvesters and tractors, out in the open, or at best under flimsy sheds. The second practice was that of leaving livestock unsheltered year-round. While these practices were defended on the basis of the mild climate, there is no doubt that other culturally derived factors are operative. It seems poor economy to leave costly machines exposed to weather when sheds are not exceptionally expensive to build.

Land improvement was reported by interviewees, but it was sometimes difficult to determine whether reference was being made to a routine operation or to a substantial improvement, such as clearing or drainage. The improvement most often reported was land clearing. Approximately one-fourth (26 per cent) of all interviewees reported this activity. Except for three farmers in Lafourche Parish, all those who cleared land lived in Tangipahoa or Madison parishes. Another important improvement practice which seems to have been introduced in the last 10 years is land leveling via a process called water leveling. A substantial number (11.5 per cent) of the farmers interviewed reported this improvement. All but two of the 25 involved lived in Acadia Parish. One out of every 10 respondents said he had improved the drainage on his farm. These farmers lived in Lafourche and Madison parishes, except for one man in Tangipahoa. Some 31.5 per cent of the interviewees did not report any type of land improvement.

Farm Workers, Laborers, and Tenants

Taking into consideration size of farms, the number of farmers (33 per cent) doing all the work on their farms by themselves was relatively high. The largest percentage of such cases, 48 per cent, was reported in Madison Parish. The percentage in other parishes ranged from 26 per cent in Lafourche to 33 per cent in Tangipahoa. Amazingly, some 28 other combinations of work were reported. When all combinations, including wife and children as unpaid laborers, are placed together, about one-third more of the farms are accounted for. Approximately one-fourth of the farms reported various numbers of hired workers and the remainder were at least partially operated with share tenants. Some 13.5 per cent of the interviewees reported working off their farms part-time. Almost three-fourths (71.5 per cent) of all farmers interviewed used seasonal labor.

It is interesting that approximately one-fourth of the farmers interviewed said they used more labor in 1967 than they did in 1957. In almost all cases these were farms which had been enlarged. However, about half of the farmers reported no change in their labor situation. In contrast, one-fifth of them used less labor than they did in 1957. This phenomenon occurred most frequently in the dairy farming area, which has moved during the 10-year period from hand milking to machine milking and to bulk tank types of operation.

Tractors and Harvest Equipment

The tractor has replaced the horse on most farms in the United States. This fact is evident from census information, but the patterns of ownership are not clear from these data. For this reason, all farmers interviewed were asked how many tractors and other self-propelled machines they owned. It was not surprising that 95 per cent of the farmers reported owning a tractor, but learning that one-fourth of them owned as many as four or more tractors was unexpected. In fact, three out of four farmers owned two or more tractors, as shown in Table 15. Many times farmers said they kept older tractors, although they were not utilized very efficiently. In this sense, they can be considered over-mechanized, although the convenience of having a third or fourth tractor at peak seasons or for special tasks apparently outweighed the sale value of the tractor in the farmer's mind.

TABLE 15.–Number of Tractors Farmers in Sample Population Reported Using on Their Farms, 1967

No. of tractors used on farms	Lafourche, St. Mary	Acadia	Tangipahoa	Madison	Total
	Per cent	Per cent	Per cent	Per cent	Per cent
One tractor	22.0	5.9	44.9	34.0	26.5
Two tractors	10.0	29.4	38.8	28.0	26.5
Three or more	14.0	37.4	12.2	12.0	18.5
One less than in 1957	48.0	25.3	2.1	22.0	24.5
No tractors (Use custom work)	6.0	2.0	2.0	4.0	4.0
	100.0	100.0	100.0	100.0	100.0

The number of tractors, of course, is not the whole story, as there are considerable differences in tractor sizes and power. The larger tractors appeared to be in the sugar cane and cotton-soybean areas. It may also be observed that the average power and speed of a farm tractor has increased considerably during the 10-year span under study. In this regard, although 45.5 per cent of the farmers had the same number of tractors as they did in 1957, their total power usage probably increased. Only 12 farmers (6 per cent) reported fewer tractors than they owned 10 years ago. Comments on this point made by farmers indicated they were much concerned with the growing trend toward higher off-farm wages and consequent shortage of labor in farm areas.

All interviewees were asked if they owned self-propelled harvest type equipment in addition to tractors. For the cane area this would normally be the cane harvester, for the rice and soybean areas the combine, for the cotton area the cotton-picker, and for the dairy area the hay-baler. Some 44 per cent of all interviewees said they owned all the harvest equipment used on their farms. Some (8 per cent) did custom work, and almost half (46 per cent) owned some harvest equipment but had to hire additional equipment for their harvest. One out of 20 farmers preferred to hire all of his harvesting machinery and owned no such equipment. The remainder did not have operations which necessitated the use of harvesting machines. Area patterns in the use of harvesting machines are shown in Table 16. This table shows that much custom work is done in all areas, but that the dairy and cotton-culture areas stand out in this respect. The latter is no doubt a function of size

TABLE 16.–Reported Source of Self-Propelled Harvesting Equipment Used by Farmers in Sample Population, 1967

Source of equipment	Lafourche, St. Mary	Acadia	Tangipahoa	Madison	Total
	Per cent	Per cent	Per cent	Per cent	Per cent
Equipment owned and used on own farm only	54.7	56.9	20.4	12.0	36.0
Equipment owned but used for custom work also	-	5.9	12.2	14.0	8.0
Equipment not all owned, makes use of custom work	38.3	33.3	55.2	58.0	46.0
No equipment owned, all done by custom work	7.0	-	2.0	8.0	4.5
No harvest suitable for self-propelled equipment	-	3.9	10.2	8.0	5.5
	100.0	100.0	100.0	100.0	100.0

of operation. However, the over-all custom work picture may purport a change in farm operation and management practices.

Patterns of Custom Work

It has been brought out that Louisiana farmers are moving toward greater use of custom work; that is, the hiring of others to do special jobs on their farms. Each of the interviewees was asked whether or not he used or did custom work. The pattern varied considerably from one area to another. In the sugar area and rice area well over half of the farmers owned all the equipment which they used on their farms, as shown in Table 16. This was not true in the dairy and cotton areas. It can be deduced from the findings reported in Table 16 that farmers in the dairy and cotton areas tend to hire neighbors. Only a few farmers in the rice area and none in the sugar area reported doing custom work for neighbors or others.

The reason why custom work is limited principally to professionals in the sugar and rice areas becomes obvious when one discovers the type of work done. Over one-third of the farmers interviewed reported hiring work done by airplanes, ranging from spraying insecticides, to fertilizing, to planting. Airplane work is, in fact, about all that was reported hired in the sugar and rice areas. By contrast, although one-third of all farmers reported other types of custom work, approximately three-fifths of the respondents in Tangipahoa and Madison parishes hired custom work other than that done by planes. It should also be stated that approximately one-third of the farmers did not use custom work of any kind and that most of these were found in the sugar and rice areas (Table 17).

TABLE 17.–Types of Custom Work Reported by Farmers in Sample Group, 1967

Type of custom work	Lafourche, St. Mary	Acadia	Tangipahoa	Madison	Total
	Per cent	Per cent	Per cent	Per cent	Per cent
Airplane: (including spraying, fertilizing, planting)	54.0	54.8	8.1	22.0	35.0
Other type of custom work	4.0	7.9	61.3	58.0	32.5
Did not use custom work	42.0	37.3	30.6	20.0	32.5
	100.0	100.0	100.0	100.0	100.0

Farm Enterprises

The important changes in farm enterprises which have occurred within the past 10 years are related primarily to production restrictions imposed by government, according to farmers. However, there has been a great change in crops and livestock produced on individual farms despite the fact that almost three-fourths of all interviewees said they were still growing the same crops and/or livestock as in 1957. The really phenomenal change occurred in Acadia and Madison parishes, where an impressive move into soybeans can be noted. In these parishes over two out of every 10 farmers interviewed had either begun planting soybeans with or after another crop or as an independent enterprise. Although no farmer in Tangipahoa reported switching enterprises, about half of the farmers there reported increases in production with the same number of milk cows. They attributed the increase to better selection of herds and more efficient practices. In this regard, it is the impression of interviewees that more improvement in quality of herds would bring production standards closer to national norms.

Sources of Farmers' Income

An attempt was also made to determine what sources of income, other than farming, each farmer interviewed had. Some 29 per cent of the total sample population reported such income. The first noticeable source of such income is from off-farm work. One-tenth of the farmers and 4 per cent of the farmers' wives in Tangipahoa reported they were holding part-time jobs off their farms. Fourteen per cent of the farmers in the rice area also reported working off the farm, but here there is a much better reason. Rice farming does not demand the type of continuous work which is characteristic of dairy farming. No part-time jobs were reported in the sugar and cotton areas.

Not unexpectedly, 10 per cent of the farmers in the cane area and 31.4 per cent of the farmers in the rice area had income from oil rights on their land. This income ranged from a mere $12 a year to as much as $2,000 per month. This type of income explains why land is virtually not for sale in these parts of the state and also helps one understand why certain farming practices persist. The remainder of the respondents reporting outside income named a number of sources such as sale of forest products, driving a school bus, and doing custom work.

Selected Farm Management Practices

It is somewhat of an incongruity to discover that despite the high level of mechanization on Louisiana farms there is an apathy which persists towards certain practices associated with good farm management. To illustrate, no less than 61 per cent of the farmers interviewed declared bluntly that they did no bookkeeping nor did they keep farm records of any kind. It is understandable, because of the size of their operations, that farmers in the sugar and rice areas more often keep books and hire bookkeepers. Interviewers got the impression that some farmers felt that systematic records were merely an effort for the benefit of tax collectors. On behalf of farmers, it must be said that personal expenses are not easy to disassociate from the expenses of operating their farms. In this connection, farmers without records were unable to give their exact total net income, but none of the interviewees reacted negatively to this query.

Farmers were queried on other farm management practices they had changed. The idea was to determine if substantially different things were being done, as compared with 1957. Four out of five interviewees said they had made such changes. Interestingly, two out of every three of them said the use of chemicals (herbicides, fertilizers, insecticides, etc.) represented not only a substantial change but the most important change in their management practices. One-fifth of the respondents named other things, such as better equipment or better use of information, as being more important. The remaining one-fifth did not feel they had made substantial changes since 1957 in the way they managed their farms.

Participation in Selected Farm Organizations and in Cooperative and Credit Arrangements

It was considered of some importance to determine whether there was a trend among Louisiana farmers toward membership in organizations such as the Farm Bureau and farm cooperatives. Each interviewee was asked to name the farm organizations to which he belonged and to indicate if he was a member in 1957.

The Farm Bureau is the most popular general type farm organization in the state. Its history dates back a number of years. Over half the interviewees (53.5 per cent) said they were members of the Farm Bureau. Four per cent said they had been members 10 years ago, but had dropped their membership. In contrast, one-tenth of the farmers queried had taken their memberships within the past decade. The remainder (42.5 per cent) had never joined this organization.

The cooperative movement has not progressed as fast among Louisiana farmers as among farmers of some Midwestern states. Yet almost half (48 per cent) of the respondents said they belonged to some type of farmers coöp. These ranged from purchasing and marketing groups to service coöps, such as rural electrification associations. The area with the largest membership was the dairy area. Here more than four of every five interviewees held membership in a coöp group. Membership in the rice area was also exceptionally high (45.1 per cent), no doubt because of coöps which were established to provide rice-drying facilities.

With the increase in size of farms and the advent of complicated and costly machines, one would expect farmers to move toward joint ownership of certain items of equipment. To test for such a trend, each interviewee was asked if he owned equipment jointly with other farmers. Responses indicated that about one-fifth of the farmers did have joint ownership arrangements and that about half of the latter had these arrangements with relatives.

It is commonly thought that mutual aid practices have disappeared or are disappearing in the face of an encroaching mass technology. Each farmer interviewed was asked if he regularly traded work with his neighbors or borrowed and loaned equipment. He was also asked to indicate if his patterns of behavior in this connection had changed during the past 10 years. The tabulation of replies indicated that mutual aid practices were actually increasing rather than decreasing. As many as 11.5 per cent of the farmers in the sample group indicated they had only begun to trade work and equipment with neighbors in the last 10 years. When this number is added to the 39.5 per cent of the farmers who had practiced mutual aid continuously for more than 10 years, it can be seen that half the farmers still follow this practice. Only two of every 100 farmers ceased to borrow and trade with neighbors in the last 10 years.

A final social participation query dealt with use of credit by the farmer and was designed to determine whether recent changes had been made in farm financing. The great majority (70 per cent) reported following the same practice they had 10 years ago. Only 3 per cent of the sample group reported that they had begun using credit since 1957. Approximately the same number had stopped this practice altogether. Interestingly, only one-fourth of the farmers interviewed were well enough off to completely finance their farm operations.

Farmers' Assessment of Their Present Status and Future Outlook

Each farmer interviewed was asked if he felt the changes which had come about in farming during the past 10 years had changed the farmers' situation. The idea of this question was to determine the farmers' subjective evaluation of the impact of change. Responses to this question were not always consistent. For one thing, it was obvious that cause and effect were often misinterpreted and that the total impact of technical innovations was interpreted in terms of personal experiences. Because of this, the categorization and analysis of responses were difficult. Nevertheless, general impressions and feelings were obtained.

Improved Farming Situation

Each interviewee was asked if he felt the changes he had made within recent years had improved his individual situation. Interestingly, only 3 per cent of the respondents felt these changes had had a detrimental effect. By contrast, well over one-fourth of the interviewees said they had better income and an easier life, or both, as a result of improvements in farming. In addition, some two-fifths of them said they were better off because they had been able to increase productivity and produce better crops. Still another 8 per cent felt they had less work now than before. The remainder, approximately one-fifth, could see no change in their lot. There was not a great deal of variation from one type farming area to the other in the responses. In this regard, farmers in the cotton area tended to name better income more frequently than other classes of farmers. Rice and dairy farmers tended to stress greater productivity. The latter no doubt reflects improvements in seed varieties and new practices that have come to the rice and dairy areas.

More Leisure

Each farmer interviewed was asked specifically if he felt he had more leisure today. Responses indicated that approximately one-third of them felt this was true. However, one out of six said he had less leisure. The remainder, a little more than half, did not feel there had been a significant change in the amount of their leisure time. Interestingly, cane and cotton area farmers were the ones who more frequently expressed a condition of more leisure. Reasons given for having more leisure were the items of technology which made intensive labor tasks, such as keeping land free of grass, much easier. By contrast, the dairy farmers were the most insistent that they did not have as much free time as before. In these areas, larger farms and the disappearance of hand workers have resulted in more work for the operator.

Role of Wives, Children Unchanged

To determine if changing times had affected the role of the wife and children on the farm, each interviewee was asked if his work demands on his wife and children had changed. The great majority, some 72 per cent, did not feel a change of this nature had come about. However, there were some area differences in this response. In the dairy area, as many as one-fourth of the respondents said their wives were now working more—a fact which can be equated to larger farms and the labor shortage. Only about 15 per cent of all interviewees said women were working less, and this percentage was about the same in all farm areas. About 3.5 per cent said their wives had stopped working on the farm altogether, and this may be indicative of a change in the future.

Visiting and Recreation Patterns

It was thought of some interest to determine if farmers felt they were doing more visiting, and indulging in more recreational activity, than before. Seven out of 10 said they were still following the patterns of years gone by. Yet it is of some importance that nearly one-fifth (18.5 per cent) said they had increased their activities of this type. This finding was in contrast to the 11.5 per cent who said they did less visiting and indulged in less recreation since technology had moved in. The long-run impact of technology on leisure is thus not clear at this time. The only thing which seems certain is that dairy farmers have less time for visiting and recreation than other farmers.

No Regular Vacations

Another question in the series designed to determine differences in farmers' use of time related to vacations. It is impressive to note that as high a number as four out of five (81 per cent) of the farmers interviewed had never taken a formal vacation. For dairy farmers, this percentage jumped to 87.8 per cent. More rice farmers (about 30 per cent) than farmers in other areas said they had taken a vacation.

A second question was designed to follow-up on the query relative to vacations. It asked if the farmer ever took days off from work. One-tenth of the respondents replied that they were in the habit of taking at least three or more days off from work during the year. About 60 per cent of the interviewees admitted taking an occasional day off, but less than three during the year. Most of these farmers were found in the rice areas, although a considerable number came from the sugar area. The remainder made statements like this: "We have no time to go to our own funeral."

It is apropos to note that the farmers interviewed seldom counted their visits to town and their leisure activities there as time off from work.

It is interesting that two-fifths of the farmers had no plan for retirement. Some 27.5 per cent had plans to stop work at age 65, and another

5 per cent planned to retire at an older age. The remainder were undecided on this matter.

Factors Responsible for Changes

Each farmer was asked to name the factor he thought most responsible for changes on farms. It is perhaps not surprising that one-fourth of them felt the question was too abstract and too difficult to answer. However, 14.5 per cent mentioned the changed labor situation as the major cause for changes on farms. Not surprisingly, this response was found most frequently in the cotton area. This is where the labor problem has had the greatest impact. Sharecropping, so common a few years ago, is literally no longer existent. One of every four cotton farmers interviewed mentioned the labor factor as most important of all factors relating to change.

The factor mentioned as most important by the next largest group was the introduction of new machines. One out of 10 (11.5 per cent) of the respondents gave this response. Chemicals were mentioned by some 6 per cent of the interviewees as being the most important factor in change, and the remainder gave a great variety of causes, such as better education, a more scientific approach to problems, better management, and change in size of farms. On the negative side, a few farmers singled out factors like the higher cost of government programs and lowered productivity of land as being most responsible for change. All in all, it is clear that farmers do not have a well-crystallized opinion as to what is the most important causal factor in explaining what has happened.

Mixed Feelings About the Future

A segment of the questionnaire used in interviewing farmers was designed to test for attitudes toward the future. A later more detailed scale-type analysis is planned for this part of the questionnaire. However, some of the responses given are interesting and provide insight pertinent to this report.

First, it is important that as many as 85 per cent of the respondents agreed or strongly agreed with the statement that farming in general had improved in the last 10 years. Only 10 per cent of them disagreed. There was not too much difference in the answers of farmers from different areas, but the cotton farmers seemed to be more convinced of the fact. By contrast, when asked to respond to the statement that farmers were more independent in their operations now than 10 years ago, there was a decided negative response. Only 50 per cent of the farmers agreed or strongly agreed with this statement. The remainder were undecided or disagreed. This behavior is significant in terms of the hypothesis expressed in the introduction to this study.

A commitment to farming as an occupation was shown in responses to a third statement. This statement suggested that farmers who could earn 20 per cent more outside of agriculture working for someone else should take the job. Only 40 per cent of the interviewees agreed in any degree with this statement, and the same number disagreed. The remainder were uncertain. The distribution of responses shows that farmers are not altogether motivated by economic factors. For some, the independence of farm life continues to have appeal.

A further statement was designed to probe the individual's commitment to farming. It read, "If a farmer's son has the opportunity to take his father's farm or of taking a non-agriculture job, his father should advise him to take the outside work." Again, just over 40 per cent of the interviewees agreed that the farmer should advise his son to take the job outside of farming. Most of the remainder disagreed, although 23.5 per cent were undecided. This pattern of responses indicated a degree of pessimism about the future of farming.

The Future of the Small Farm

Every interviewee was asked to assume current conditions and trends and to estimate the minimum acreage that would be needed in 1980 for the type of farm he is now cultivating. Only five interviewees estimated a farm of less than 50 acres. One in four projected a farm ranging in size from 100 to 150 acres. Approximately 30 per cent thought a farmer would have to have from 150 to 300 acres to handle their present enterprises, and as many as 25 per cent felt that farms in their area would have to range from 300 to 1,000 acres. Almost one of every 10 farmers responded that he or farmers like him would need over 1,000 acres in 1980. Interestingly, more than half felt their present farms would have to be at least one-third larger to be profitable in 1980.

Responses to the above question varied somewhat from region to region, as might be expected. Dairy area farmers projected the smallest size farms. The significant point is that nobody believed in the future of the small farm.

When asked if they thought they or others could achieve the size farms they will need in the future, the majority of respondents were pessimistic. Approximately two-thirds of them did not think they or their fellows could achieve this much acreage. They saw no alternative for some farmers but to quit the business and look for other jobs. When asked if they thought there were things the smaller farmer could do to improve his income problems, a variety of answers were given. Thirty per cent said more mechanization might help. Other miscellaneous comments were that improvements in labor conditions, in education, and in credit might be the solution.

Impressions and Observations of a European

A. K. Constandse

Louisiana is not, of course, representative of all the United States. In fact, no state is. Nevertheless, the average European has a stereotyped image of American agriculture as large-scale, mechanized farming. With this image in mind, the European who has an opportunity to study Louisiana agriculture firsthand receives some shocks. The following observations give some idea of those things which impressed me as a Dutch rural sociologist doing his first field work in the United States.

The farms in Louisiana indeed were larger than in Europe, on the average, but the number of acres was often misleading. Most farms included considerable acreages of wasteland or of rough grazing land. Not all land was intensively used as is common in Europe. Although the use of fertilizer has increased on farms here in recent years, the yields per acre and the number of cattle per 100 acres are considerably below that found in areas with intensive agriculture in the Netherlands, Germany, Denmark, or parts of France. (It may be noted that Louisiana averages are also below the average of the U.S.A.)

Surprising to the European is the tendency to monoculture in Louisiana: sugar cane and nothing else; rice and nothing else; dairy and nothing else; sometimes soybeans only. Consequently there is more fallow land than in areas with a greater variety of crops rotating in a 7-year period, as found in European regions. With the exception of the dairy farms, the load of work on the farms studied appeared heavily concentrated in a few short periods when there was a shortage of labor. Sometimes for long periods the farmers did not have much to do on the farm. This was particularly clear in Acadia Parish. Mechanization, which is far advanced, increases this disequilibrium. It reduces the harvest and planting season to a small number of days and makes the laborless periods longer. Some farmers take advantage of this fact by taking a second job, a practice only common among small land holders in Europe.

The total amount of labor on many of the farms studied was reduced by the fact that several of the mechanized operations could not be carried out by the farmer with his own equipment. This was most obvious where flying services were used. A part of the work in the rice area, and also in other areas, was taken over by custom workers. In this regard, it is not surprising that many of the farmers interviewed mentioned 'chemicals' as the biggest change which had come in recent years. The use of herbicides relieves them of the arduous task of hoeing.

The total amount of work for the U.S. farmer is increasing because of the trend toward enlargement. At the same time, the labor force is staying about the same or even decreasing. A striking difference in comparison with most European countries is that enlargement of farms is relatively easy here. There is more mobility, and it seems that the tendency is less strong to keep a farm as a family property. The emphasis is more on *land* as such, than on the holding as a unit. Mobility in the U.S. is, perhaps, made easier because buildings are of minor importance. In colder climates, stables and barns demand a big investment and are frequently a status symbol for the farmer. The Louisiana farmer has only some sheds which often appear ready to fall to pieces. Machinery and trucks are often kept in the open all year, sometimes nearly covered by weeds. It is hardly possible to judge by looking whether the farm is big or small, prosperous or not.

Farms in Louisiana were similar to those in Europe in the sense that the great majority of them were family farms. Also, as in Europe, many of the farms used more hired labor (or sharecroppers) in the recent past. As the productivity of labor increases a family may easily outgrow the farm. This seems less of a problem than in Europe, because one can enlarge farms here more easily. This is made possible by the fact that many families stop farming and/or go to the city, and lease their land out.

With a few exceptions, talking about the future with farmers in Louisiana implies talking about the future of the family farm. The fantasy does not encompass basic changes except in terms of "more" and "bigger" operations.

An interesting aspect of farming in Louisiana was the absence of economic self-rating; that is, of sharp accounting. One would expect that farmers who had developed such a high degree of technology would employ economically sound systems of records. The main pattern found, however, was the absence of formal bookkeeping. The farmers know in a general way what comes in, they pay their debts, pay for seed, fertilizer, etc., and they live on what remains. However, they have only a vague idea of what their net income is. Also, hours of work are not counted. They say they work all the time and consequently they do not place a value on their hourly work.

In dairy farming, the only type of farming in which the wives were found to work frequently in Louisiana, there is an awareness of the many hours of work and of being tied to the farm 7 days of the week.

Louisiana dairy farmers are technically ahead of most European farmers, particularly in the use of labor-saving equipment (pipelines, bulk tanks, etc.). However, the dairy herds are often in bad shape and not registered in the herdbook.

The grassland or pastureland also appears to be poorer here.

Taking into account the opportunities the American educational system gives to everybody, the level of education of the farmers in Louisiana was surprisingly low. In the southern parts of the state this phenomenon is partly explained by the language problems of the older French-speaking generation. This low level of education (sometimes illiterates were met) may explain the reluctance to start bookkeeping and other records. It is certainly not directly related with traditionalistic attitudes in all fields. New farm practices are readily adopted, technical skills are highly valued and the significance of science for agriculture was well understood by most Louisiana farmers. This does not mean that all older values have been thrown away; the belief was found to remain that personal care in small enterprises is of utmost importance in farming, particularly in cattle farming. The farmers have, in general, a rather high opinion of themselves as being good, hard-working people.

Curiously, the self-image of farmers in Louisiana does not seem to lead to that kind of pride so typical for farmers in many regions of

Europe, which leads to a persistence of living on a low-income even if better job opportunities are at hand. A farmer with 50 dairy cows in a country like Holland certainly feels himself superior to a worker in a factory. A Tangipahoa Parish dairy farmer in Louisiana, who works as a mechanic while his wife is taking care in the main of the 50 dairy cows, is nothing unusual. In Europe this would be a rarity.

In closing, it may be noted that complaints about increasing costs and too low prices of products were heard in Louisiana. However, when compared to Europe where milk, wine, and meat prices have even led to rioting of farmers (in France) or to extremist right wing voting, the reactions here appear to be very mild.

Summary and Implications

The study reported here was designed to record at a point in time the impact of increasing technology on agriculture and rural life in Louisiana. It was undertaken in an effort to understand evolving trends in Louisiana and as a contribution to a national and international project set up for the purposes of comparing changes in rural life in many different cultural settings. A simple analytical approach utilizing data from the national census and a field survey was used to indicate emerging patterns of behavior. The following are general findings of the study:

1. The number of tractors and trucks on farms has continued to increase during the past 20 years, although the rate of increase has slowed down in recent years.

2. Draft animals are no longer a conspicuous part of the Louisiana farm scene and hogs and sheep are losing popularity. However, cattle and chickens are increasing in number on farms.

3. The number of owner-operated farms is decreasing, but the percentage of such enterprises is increasing rapidly in the face of a diminishing number of renters. These trends have been accompanied by a drastic drop in the number of farm laborers in recent years.

4. Farms in Louisiana have shown a striking increase in size in the last 20 years, growing from an average of 77.6 acres in 1944 to an average close to 170 acres. Farms of less than 50 acres have decreased by two-thirds, while farms of 500 acres or more have become as common as farms of less than 10 acres.

5. The state is becoming much more commercialized in its farming, with a sharp increase noted in farms with over $10,000 in annual sales. By contrast, very few farms remain, relatively speaking, which have sales of less than $5,000 per year.

6. Levels of living of farmers are rapidly improving as measured by ownership and/or possession of automobiles, T.V. sets, telephones, and home freezers.

7. The farm population of the state is getting considerably older at the same time that a greater balance between the sexes is being estab-

lished. The quality of the farm population, as measured by educational attainment, is improving greatly although the picture is still not bright by comparison with urban dwellers.

Certain specific features of the changing rural scene in Louisiana were determined through a field survey involving interviews with approximately 200 farmers selected randomly in five parishes representative of broad type-farming areas. The farmers chosen to represent the sugar cane area were from Lafourche and St. Mary parishes; those selected to represent the rice area were from Acadia Parish; those for the dairy area from Tangipahoa Parish; and those for the cotton area from Madison Parish. Findings from the interviews may be summarized as follows:

1. Clearly the great majority of farms in all parts of the state are individually operated. However, there is a growing number of partnerships which indicates a trend toward formalization of working agreements between family members and between co-owners or operators.
2. Farms vary considerably in size from one part of the state to another, with the rice area having the largest percentage of farms over 150 acres.
3. Most farms have only one or two major enterprises and many have a substantial acreage not in cultivation.
4. Tenure patterns were found to vary considerably from one part of the state to another. Well over four-fifths of the farmers interviewed in the dairy and cotton areas owned all or more than 50 per cent of their land. By contrast, about three-fifths of the farmers in the rice and sugar areas rented over half their land.
5. Relatively few farmers interviewed used full-time laborers, although almost three-fourths of them used seasonal workers.
6. Almost three out of every four farmers interviewed had other sources of income, ranging from their wives working in town to oil royalties.
7. The cooperative movement is gradually spreading over the state with farmers in the dairy and rice areas leading the way.
8. Joint ownership of equipment, trading of work and equipment, and custom work are common practices used to offset the high cost of mechanization.
9. Changes in farming practices are attributed primarily to government regulations, including such a dramatic change as the shift to soybean production in all parts of the state.
10. Most farmers own more than one tractor and many tend to be overmechanized.
11. Improvements on farms tend to be tied to technological changes, such as bulk tank milk facilities and irrigation practices. Farmers interviewed tended to feel that the growing use of chemicals represented the most significant technological advancement in agriculture within recent years.
12. Farmers generally feel that the recent changes have improved their situation by increasing their income, increasing their leisure, and

in general making their life easier.

13. Farmers, as a rule, do not see much change in the roles played by wives and children on farms.

14. The visiting and recreation patterns of farmers have not changed much and few of them take formal and regular vacations.

15. Farmers do not have a well-crystallized opinion about what has happened and have mixed feelings about the future.

16. Farmers are pessimistic about their future and project the feeling that small farms are doomed to die.

It is clear from the above findings that technology is increasing on farms in the state and that this trend is responsible for rather profound changes in farming and rural life. The most striking aspects of this change are the increasing size and commercialization of farms coupled with a decreasing number of farms and of laborers and tenants. The increasing role of government in farming is also obvious, as is the increasing necessity to depend upon outside assistance for financing, processing, and marketing operations. All of these changes tend to vary in degree and rate from one type-farming area to another.

There is evidence that it is difficult to adjust mechanization and some other aspects of technology to farms. The tendency seems to be to overmechanize at the same time that there is an uneasiness about how far mechanization should go. All in all, farmers seem to be headed toward large, highly-capitalized operations, employing a high degree of technology. They face the future with mixed feelings about what the ultimate outcome will be for the individual entrepreneur. Indications are that farming is gradually becoming a complex and tremendously demanding type of productive enterprise, one which technology is taking beyond the capability of a single operator.

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Controlling Bloat In Cattle Grazing Clover

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Controlling Bloat in Cattle Grazing Clover

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Summary

Research was conducted on prevention of clover bloat in cattle during the years 1958 through 1962, and 1964 through 1967. It was found that properly managed, young, fast growing Ladino clover plants were of high bloat induction potential and provided a reliable means of evaluating the effectiveness of bloat preventives in cattle.

It was demonstrated that death of cattle due to clover bloat is not caused by a chemical phenomenon but rather by excessive intraruminal pressure (physical) which prevents diaphragmatic contractions, and therefore respiration, followed by heart failure.

Penicillin administered to individual cattle daily by mouth in a gelatin capsule with a balling gun, and penicillin provided free choice in salt, prevented severe and lethal clover bloat in cattle for one to two weeks.

"Pets," a combination of penicillin, erythromycin, tylosin, and streptomycin, provided free choice to cattle in a pelleted feed, prevented severe and lethal clover bloat in cattle for 46 days.

"Step" boluses, also a combination of the antibiotics referred to above, prevented severe and lethal bloat in steers for one month. Each steer was administered two boluses by mouth at the beginning of the treatment period.

Resistopen, a semisynthetic penicillin, administered every other day by mouth in a gelatin capsule with a balling gun, also prevented severe and lethal bloat in treated cattle for four weeks.

The use of antibiotics and poloxalene showed promise in preventing clover bloat in cattle; however, the use of antibiotics did not prove practical.

Poloxalene, a nonionic surfactant, in salt-molasses blocks (30 grams per pound of block) when used judiciously is an effective, practical, and economical means of preventing severe and lethal bloat in cattle grazed on clover with high bloat induction potential.

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Introduction and Review of Literature

According to Tribe (*45*)[5], bloat was recorded in literature by an ancient Roman author as early as A.D. 60. Recently it has been defined as a noninfectious disease *(28)* which is common in ruminants in many parts of the world. Legume (clover and alfalfa) bloat in ruminants results from the accumulation of stable foam (froth) in the rumen (paunch) which prevents eructation or belching (*11, 29*). Stable froth accumulates in rumens of cattle which bloat on feedlot rations, but the mechanism of pasture (legume) bloat and that of feedlot bloat are not the same (*47*). It is estimated that the morbidity and mortality due to bloat costs livestockmen 100 million dollars annually *(46)*. The great loss in Louisiana, however, is due to the fact that clover, a high-quality forage, in recent years has not been generally used in pasture improvement practices. Cattle will gain up to 2.5 pounds per head per day when grazed on good clover. In addition, clover will fix from 50 to 250 pounds of atmospheric nitrogen per acre each season depending on density of stand, growth produced, length and nature of growing season, soil fertility, and degree of effective inoculation of clover seed with symbiotic bacteria (*47*). High-quality grasses may accompany and/or follow the growth of good stands of clover.

The mechanism of clover bloat is complex and logically results from the proper interaction of bloat inducing plants that are consumed in sufficient amounts by bloat susceptible cattle or sheep, and the ruminal microbial population.

Plant Factors

Young, fast growing, succulent plants are essential for the production of clover bloat in Louisiana. It was reported that lush Ladino clover had a greater bloat induction potential than did common white or Louisiana S–1 clover (*32*). It is probable that more than one substance in clover is present in sufficient quantities to induce bloat in ruminants.

It was reported that alfalfa saponins (*35*) may be important in the production of stable foam. However, another report (*4*) indicated there was little correlation between saponin content and bloating potential of clover and other legumes.

Several reports (*13, 14, 23, 24, 25, 40, 41*) indicate that pectin and/or pectic substances play an important role in the production of stable foam in legume bloat. Girouard (*23*) reported that the total pectic substances in well-managed, rapidly-growing Ladino clover varied from 9.41 to 10.98 per cent as compared with 4 per cent of the same substances in alfalfa hay.

The crude protein content of Ladino clover was reported to vary from 23.2 to 27.5 per cent, as compared with 16.1 per cent for crude protein in alfalfa hay (*23*). It has been suggested that the foaming agent in legumes which causes bloat is probably a cytoplasmic protein (*37*). Recently it has been identified as the 18-S protein, which is a chloroplastic protein (*38*).

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[5] Italic numbers in parentheses refer to Literature Cited, page 26.

Animal Factors

It has been reported that nonbloating cattle have higher levels of sera epinephrine than do cattle that bloat (*16*). The importance of saliva in preventing bloat has been reported (*9, 11, 39, 49*). Some researchers indicate the important animal factor that prevents bloat is the mucin in saliva (*6, 18, 36*). They suggest that if the ruminal flora of a ruminant grazing legume pasture is composed of mucinolytic bacteria, which destroy the mucin, bloat will result. It is also suggested the disease will result if inadequate amounts of saliva are secreted (*6*). Studies at this station, using Ladino clover pastures with high bloat induction potential, showed some wide variations in bloat severity of the same animals from the morning to afternoon grazing periods of the same day, as well as variations in bloat severity of the same animals after corresponding grazing periods from day to day. This suggests that the cause of clover bloat is quite complex and possibly results from several interacting plant, animal, and microbial factors.

Microbial Factors

Certain types of ruminal bacteria (*6, 8, 18, 26, 36*) and ruminal protozoa (*10, 34*) have been reported to be associated with bloat production. It appears that the bacteria and/or protozoa are very important factors in clover bloat, because bloat-susceptible cattle must graze clover pastures with excellent bloat induction potential for two to three days and some animals must graze clover for two weeks or more before they bloat. This suggests the ruminal microbial population probably must undergo definite changes before stable foam is produced and bloat results.

It appears that legume bloat in ruminants results from the interaction of more than one plant, animal, and microbial factor discussed above. Future research may reveal additional plant, animal, or microbial factors which are very important in bloat production.

Bloat Prevention

Various methods and materials have been used to prevent clover bloat in cattle. Hay has been fed cattle before turning them to clover pasture, and this has apparently given good results in preventing bloat in some instances. Some stockmen have pastured grass and clover alternately to prevent cattle from bloating, with apparent good results. However, such a practice demands constant attention, and this increases costs.

Antibiotics (*2, 3, 19, 20, 33*) have been used to prevent legume bloat in cattle with good results, the effect varying from seven days to four weeks or longer. Combinations of antibiotics were generally effective for longer periods of time than were antibiotics used singly. One investigator (*17*) reported that antibiotics (penicillin, erythromycin, tylosin, and streptomycin) caused undesirable digestive effects in experimental cattle. The same antibiotics used in slow-release boluses gave good results when the boluses were not regurgitated by the cattle (*19*). The use of antibiotics in bloat prevention lost favor because of the uncertainty of getting all animals to consume the required daily amounts when offered in grain or salt-antibiotic mixtures, and also because some of the antibiotics were not approved by the Food and Drug Administration for use in bloat prevention.

Alkyl aryl sulfonate sodium has been reported to be effective in preventing bloat in cattle grazed on alfalfa (*41*). Reportedly this substance is a plant enzyme inhibitor (pectin methyl esterase), and can be fed daily to cattle in a grain mix to prevent bloat. Getting cattle that are grazing on lush clover pastures under range conditions to consume adequate quantities of this material in a grain mix probably would be difficult.

Various other materials such as animal, vegetable, and mineral oils, detergents, and surfactants have been used as bloat preventives (*7, 12, 15, 29, 30, 31, 42, 43, 44, 48*). None of these have proved practical.

Poloxalene, a nonionic surfactant, has been used as a legume bloat preventive (*5, 21, 22, 27*). Recent research (*1*) indicated that poloxalene had no effect as a treatment on rumen pH of cows grazing Ladino clover, nor did it cause the pH to vary with the rumen strata. Although it is not ideal, it has practical application in the management of beef and dairy cattle grazed on good clover pastures.

Experiments by the Louisiana Station, 1958-67

Pastures and General Management

During the spring of 1958 clover bloat studies were conducted on approximately eight acres of Louisiana S-1 white clover. After the 1958 study, 22 acres of land close to an irrigation well were assigned to the bloat project. Equal portions of this land were planted in Ladino, Louisiana S-1, and common white clover in the Octobers of 1958, 1959, and 1960. Beginning in the fall of 1961, only Ladino clover seed was planted. Good stands of clover were obtained each year with the exception of the fall of 1962, when climatic conditions prevented growth of the newly seeded clover. Therefore, bloat research was not conducted in the spring of 1963.

Each spring the clover was clipped and irrigated periodically to ensure rapidly growing clover plants with high bloat induction potential, and the 22-acre field was divided into three or six pastures of approximately equal size to facilitate proper management of the cattle on the clover. Experimental cattle were grazed twice daily, with the morning grazing periods of two hours starting at 6:00 A.M. and the afternoon grazing periods of two hours at 3:00 P.M. This routine was followed except during spring and summer months of 1964, 1965, and 1967, when the bloat induction potential of the clover was so high that each grazing period (morning and afternoon) had to be periodically reduced by increments of 15 minutes to prevent the development of lethal bloat in the control animals. Grazing periods as short as 30 to 50 minutes were used in 1964, 1965, and 1967.

All cattle used in the experiments had been maintained on hay, grass pasture, or both before they were placed on clover. Therefore, it was necessary each year to condition the cattle to bloat, i.e., graze them on clover for a number of days before a representative percentage of the cattle bloated. This part of each experiment is referred to as the conditioning phase and preceded the treatment phase. The cattle were individually identified with neck numbers or hip and neck numbers.

Between grazing periods the experimental cattle were placed in holding lots adjacent to the clover pastures. Water, salt, and shade were available.

The experimental cattle were observed for at least one hour after each grazing period, and incidence and severity of bloat of each animal were graded and recorded according to the following scale:

0 – No bloat. No distension.
1 – Mild bloat. Obvious distension of left paralumbar fossa.
2 – Moderate bloat. Pronounced abdominal distension of both left and right sides with frequent defecation or urination, or both.
3 – Severe bloat. Animal very uncomfortable with rapid respiration, frequent lying down and arising, walking backwards, open mouth breathing, kneeling, etc.
4 – Lethal bloat. Animal down and unable to rise, with cessation of breathing. Death is certain unless rumenotomy is performed and/or artificial respiration is applied.

1958 Procedure I

A. A new stand of Louisiana S-1 white clover was grazed, starting in mid-March, with a mixed herd of yearling steers and dry dairy cattle for two 2-hour grazing periods daily. This study was conducted to determine conditions necessary for production of experimental bloat. The cattle were grazed on clover 12 inches high. In early May the dairy cattle were replaced with additional yearling steers. The clover grazed by these cattle was six to eight inches high.

B. Samples of clover grazed by experimental cattle were taken periodically to determine the nitrate-nitrogen content of the forage.

1958 Results and Discussion I

A. Dairy cattle, with one or two exceptions, did not show as much bloat as yearling steers. Bloat incidence was highest when the cattle grazed rapidly-growing immature clover which had received rain within the previous two days. Little bloat was observed when the cattle grazed clover 12 inches or more in height. The onset of maximum temperatures exceeding 90° F slowed clover growth and eliminated bloat incidence.

B. Nitrate-nitrogen content of clover grazed by experimental cattle showed a wide fluctuation which coincided with incidence of rainfall. There was a tendency for high levels of nitrate-nitrogen to be associated with bloat incidence.

1958 Procedure II

During the period of March 31-May 3, 1958, a controlled field experiment under range conditions and using a salt-penicillin mixture to prevent bloat was arranged with a local cattleman. The cattle consisted of 134 grade Brahman-Hereford cows, most of which had calves, and five Hereford bulls. These 139 animals were divided into control and experimental groups. The control cattle, Group 1, consisted of 35 cows and one bull; the treated cattle, Group 2, consisted of 99 cows and four bulls. The two groups were placed in separate but adjacent pastures of nearly pure stands of Louisiana S-1 white clover. During the two-week period previous to the initiation of the experiment several cows had died of bloat while grazing these pastures.

Group 2 was provided "Mortons" salt-penicillin mixture, free choice, in a covered mineral box, with the supply being replenished as needed during the experimental period. Group 1, the controls, received no mineral supplement. Both groups were checked for bloat daily between 2:00 P.M. and 4:00 P.M. During periods of high incidence of bloat the cattle were also observed during the mornings.

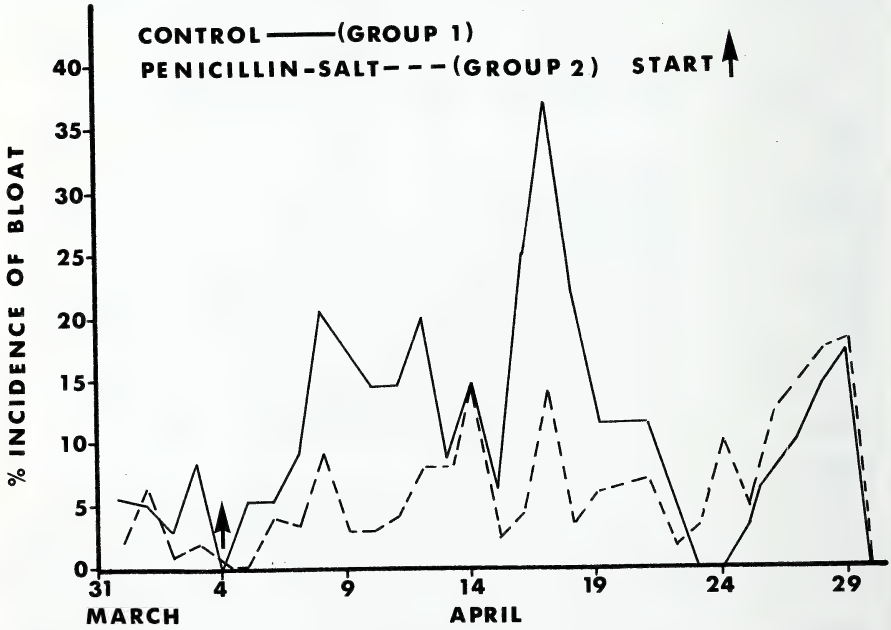

FIGURE 1.—Effects of the use of penicillin in salt on the incidence of bloat in cattle grazing clover pasture under range conditions.

1958 Results and Discussion II

As shown in Figure 1, the salt-penicillin mixture apparently reduced bloat incidence in Group 2 during the first two weeks of the study. Beginning on April 19 through April 24 it appeared that the clover did not induce bloat in the control or treated cattle. However, from April 24 through April 29 the clover induced bloat in both the control and treated cattle. During this time it was apparent that penicillin lost its effectiveness. After April 30 the clover stopped growing. One animal in Group 1 died during the third week of the study. No animals in Group 2 died; however, several were treated by trocarization or with "Turcapsol," a commercial remedy. The experienced herdsmen believed that the animals would have developed lethal bloat if they had not been treated.

There was no way to determine whether all the cattle provided the salt-penicillin mixture consumed the material daily. Therefore, it was difficult to evaluate the study.

1959 Procedure

Studies were conducted to determine differences in bloat incidence among breeds of cattle and differences in the tendency of animals to bloat on three varieties of white clover. Studies of climatic factors and possible influence in day-to-day variations in bloat incidence were conducted concurrently. Twenty-two acres of Mississippi River bottomland were divided into three plots of approximately equal size. One was seeded to common white clover, one to Louisiana S-1 white clover, and one to Ladino clover during the fall of 1958.

On April 1, 1959, the herd of cattle was placed on the clover. The herd consisted of 15 aged Brahman cows, 10 aged Angus cows, four aged Hereford cows, nine yearling Hereford steers, seven 2-year-old heifers (five Holsteins, two Jerseys), and one fistulated Holstein cow. Aged cows were eight to nine years old. On April 24 the cattle were divided into three groups so that breed and age groups were represented nearly equally in each group. From April 24 to May 20 each group was grazed on each of the varieties of clover. Animals were rotated among groups during the study. During the period from May 28 to June 18 the Hereford, Angus, and Brahman cows were replaced by a herd of 28 Hereford cows and one bull. The cattle were grazed on varieties of clover as growth permitted during the second period. Throughout both periods the cattle were grazed two hours each morning and two hours each afternoon.

Daily maximum and minimum air temperatures, solar radiation, and rainfall were plotted against incidence of bloat from April 21 to May 20 and from May 28 to June 17 to identify changes in one or more climatic variations with bloat incidence.

1959 Results and Discussion

The percentage incidence of bloat observed on Ladino, Louisiana S-1, and common white clovers was 70, 62, and 62, respectively. The significantly higher percentage incidence of bloat on Ladino clover may have been associated with the rate of growth of the clover since Ladino produced considerably more forage than the others and developed very few seed heads during the study. The other two clovers were well seeded out throughout the study.

The percentage incidence of bloat in Brahman, Angus, and Hereford cows, Hereford steers, and dairy cattle was 45, 74, 68, 51, and 61, respectively. The Brahman cows and Hereford steers bloated less than the other three groups. However, in spite of the relatively low incidence of bloat in the Brahman cows and the Hereford steers, two in each of these groups died of bloat during the study. No deaths occurred in the other groups. The average percentage of bloat incidence in all groups for the morning and afternoon grazing periods was 54 and 60, respectively.

This study indicated that there are differences among clovers and breeds of cattle relative to bloat incidence. However, there is a good possibility that cattle of any breed will bloat on any of the clovers used in this study if the plants are young and in a state of rapid growth. Incidence of bloat was not significantly correlated with daily maximum or minimum air temperatures, solar radiation, or rainfall during the experimental period.

During the study one yearling Hereford steer was observed as he advanced from a number 1 bloat through numbers 2 and 3 and then to a number 4, or lethal bloat, at which time he went down and ceased to breathe. His heart continued to beat even though his tongue was cyanotic and his eyes "glassy" in appearance. A four-inch incision was made on the left side in the upper paralumbar area (flank) through the skin, fascia, and muscles and into the rumen. Intraruminal pressure (foam and gas) was released through the incision, and artificial respiration was applied until natural breathing was established and the life of the steer was saved. This phenomenon has been demonstrated during the last few years in many animals which developed lethal bloat. This illustrated that death of cattle due to clover bloat occurs because bloated cattle cannot eructate (belch), and excessive intraruminal pressure against the diaphragm prevents diaphragmatic contractions and respiration. Until this research was reported and recorded by moving pictures, many researchers explained the death of bloated cattle by the "Toxic Factor Theory" (*42*). This theory suggested that the death of bloated cattle was due to the production of hydrogen cyanide or hydrogen sulfide or histamine, or to the presence of flavone in the bloat-producing plants, or to an "unknown toxic factor."

As indicated above, death of a bovine due to clover bloat results from the excessive physical pressure against the diaphragm which will not permit it to contract. Therefore, respiration is terminated and a minute or so later the heart stops beating because of anoxemia.

1960 Procedure

A. The effectiveness of two antibiotics, oleandromycin and penicillin, in the prevention of bloat was studied. Thirty-two head of yearling steers were available for the study. The cattle were Hereford, Angus, and dairy breeds. Twelve steers (Group 1) served as controls, 10 steers (Group 2) were fed penicillin in corn-and-cob meal, and the remaining 10 steers (Group 3) were fed oleandromycin in corn-and-cob meal. The penicillin and the oleandromycin were mixed with corn-and-cob meal at the rate of 50 milligrams per pound of meal. Group 1, controls, was provided one pound of meal per steer per day, Group 2 was provided one pound of penicillin meal per steer per day, and Group 3 was provided one pound of oleandromycin meal per steer per day. Each group was provided its respective meal just prior to the afternoon grazing period. The three groups of steers were grazed on clover two hours each morning and each afternoon daily for approximately one month. Each group was held in its respective holding lot between grazing periods.

B. In a concurrent experiment, rumen-fistulated cows were used to determine the effect of alfalfa hay and Ladino clover pasture on the rate of digestion of ground alfalfa hay and fresh Ladino clover *in vivo*. Nylon bags with alfalfa hay and nylon bags with Ladino clover were placed in rumens of cattle fed only alfalfa hay. Digestion of the contents of the nylon bags was determined at given time intervals.

1960 Results and Discussion

A. The incidence of bloat in the steers fed penicillin (Group 2) and the steers (Group 3) fed oleandromycin was not significantly different from that in Group 1 (the controls). No animals died of bloat in any of the three groups during the study. The negative results of these studies could not be explained, since previous work at this and other stations indicated that both antibiotics were bloat preventives.

B. During the first three hours Ladino clover seemed to stimulate rapid digestion of the clover in the nylon bags suspended in the rumens of cows. However, total 24-hour digestion was greatest in the nylon bags placed in the rumens of cows fed alfalfa hay. Rapid digestion of clover probably contributes to a great extent to the production of bloat.

1961 Procedure

A. A combination of antibiotics known as "Pets"[6] (40 milligrams of penicillin, 70 milligrams of erythromycin, 70 milligrams of tylosin, and 70 milligrams of streptomycin per pound of pelleted feed) was tested for bloat prevention. The pelleted feed was made up of 90 per cent wheat middlings and 10 per cent molasses. The experimental cattle consisted of 44 1- and 2-year-old steers of Hereford or Angus types, three Jersey cows, and four rumen-fistulated dairy cows, or a total of 51 head.

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[6] Supplied by Eli Lilly and Company, Greenville, Indiana.

Three approximately equal sized pastures of Ladino clover, Louisiana S-1 white clover, and common white clover were used during the trial. Each variety of clover was further subdivided into two equal plots by means of an electric fence. The cattle were grazed two hours each morning and afternoon and held in drylot with shade, water, and salt available. Six of the animals died with lethal bloat during the conditioning period of eight days. During this time each animal was graded for bloat after each grazing period. Forty of the remaining cattle were then randomly divided into two groups of 20 head each.

The treated cattle, Group 2, were fed the antibiotic-containing pelleted feed and the control cattle, Group 1, were fed the untreated pelleted feed during the period from May 11 through June 26. Groups 1 and 2 grazed the same variety of clover each grazing period, and incidence and severity of bloat for each animal after each grazing during the experiment were recorded.

B. Four fistulated cows, two grazed on clover and two held in drylot and fed alfalfa hay, were used as host animals for nylon bags to determine dry matter digestibility and the effect of PETS on dry matter digestibility. The experiment was replicated six times. One animal of each pair was given the same pelleted feed containing PETS. Four bags of freshly plucked clover and four bags of ground alfalfa hay were placed in the rumen of each of the four cows. Bags of clover and alfalfa were removed from each cow at 1-, 2-, 4- and 24-hour periods for analysis.

1961 Results

A. The overall incidence of bloat was 37.28 per cent for Group 1 and 10.53 per cent for Group 2 for the 46-day experimental period. One steer in Group 2 refused to eat the PETS supplement at any time during the experiment, and from time to time during the experiment other steers in this group also refused to eat the PETS supplement. Three steers in Group 1 died with lethal bloat during the study but none died in Group 2. The average severity of bloat was greater in Group 1 than in Group 2. Data on Ladino clover grazing periods taken separately showed an overall per cent incidence of bloat of 49.2 and 12.3 for Group 1 and Group 2, respectively. This again proved Ladino clover was more efficient in producing bloat than Louisiana S-1 or common white clover. The steers in Group 2 (treated) gained 0.16 pound per steer per day more than did those in Group 1 (controls).

The data indicated the antibiotics did not lose bloat preventive effectiveness during the 46-day experimental period, and there was no evidence that the antibiotics had any effect on the appetites of the animals. However, it is doubtful whether cattle under practical range conditions will eat sufficient amounts of the pelleted antibiotic-containing feed to prevent clover bloat.

B. The addition of PETS to the ration of the fistulated cows reduced the dry matter digestibility of both clover and alfalfa. As was expected, there were highly significant differences in digestibility among time intervals, i.e., among the lengths of time the bags were left in the rumens and exposed to digestive processes. The antibiotics were effective in reducing the rate of digestion of dry matter during the first four hours after being placed in the rumens. This study suggested that some fraction other than cellulose was digested rapidly when the antibiotics were not fed to the animals.

1962 Procedure

Slow-release antibiotic boluses,[7] each weighing approximately 63 grams, were used in bloat prevention studies. The boluses contained (S) streptomycin, (T) tylosin, (E) erythromycin, and (P) penicillin (STEP).

Available cattle were conditioned to bloat for two weeks by grazing them on Ladino clover for two hours each morning and each afternoon. They were graded for bloat after each grazing period. During the conditioning phase of the study five cattle died with lethal bloat.

After the conditioning period, the 30 cattle (13 yearling steers and nine 2-year-old steers, all of Hereford or Angus types, three Jersey cows, four Holstein cows, and one Brown Swiss cow) were randomly divided into Group 1 (control) and Group 2 (treated). Each group consisted of 15 cattle. Each animal in Group 2 was administered two STEP boluses with a balling gun on May 1, 1962. None of the cattle in Group 1 were treated. Groups 1 and 2 were managed as one herd during the study, which was terminated June 5, 1962, because the clover stopped growing.

1962 Results

Three animals in Group 1 (controls) died with lethal bloat and none were lost in Group 2 (treated) during the experiment. The per cent incidence of bloat for the control cattle, Group 1, was 56.4 as compared with 10.2 for the treated cattle, Group 2. This difference was significant ($P<.01$).

An interesting and important aspect of the study was that four boluses were found in the holding lot the morning of May 3. Either two, three, or four animals had regurgitated boluses, which were administered May 1, after one, two, or three clover grazing periods.

Cattle in Group 1 gained 1.54 pounds per animal per day and cattle in Group 2 gained 2.26 pounds per animal per day. This was a significant difference in favor of the treated cattle.

Three animals were slaughtered approximately eight weeks after they had been administered the boluses. The boluses were found in the reticulum of each steer. Apparently the boluses were too heavy to be moved over the rumino-reticular fold into the rumen. It was surprising that the boluses had not disintegrated more. Only approximately 10 grams of each recovered bolus had dissolved in the reticula of the cattle.

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[7] Supplied by Eli Lilly and Company, Greenville, Indiana.

1963

Research was not conducted in 1963 because climatic conditions prevented growth of clover planted in the fall of 1962.

1964 Procedure

Resistopen,[8] a semisynthetic penicillin, which is resistant to inactivation by penicillinase and acid hydrolysis, was used to control bloat in steers grazed on Ladino clover. Twenty-six head of yearling Hereford steers were conditioned to bloat and then randomly divided so that 13 steers were used as controls, Group 1, and the remaining 13 were placed in treated Group 2. The study included conditioning, treatment, and post-treatment periods as indicated by arrows in Figure 2. During the treatment period of four weeks, the treated steers were administered 250 milligrams of Resistopen every other day by mouth in a gelatin capsule with a balling gun.

1964 Results

The average daily per cent incidence of bloat in control steers, Group 1, was 78.1. Two steers in this group died with lethal bloat during the treatment period. The average daily per cent incidence of bloat in the

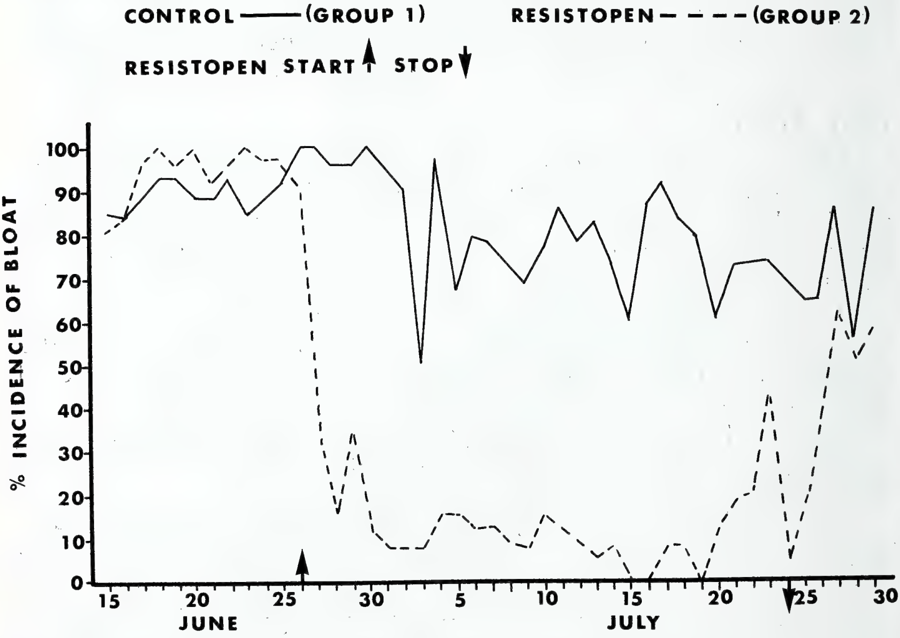

FIGURE 2.—The effects of the use of 250 milligrams of Resistopen administered to steers via a balling gun every other day on the average daily bloat incidence in cattle grazing lush Ladino clover.

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[8] Supplied by the Squibb Institute, New Brunswick, New Jersey.

treated steers, Group 2, was 12.9. None of the steers in Group 2 died. The difference between the results in Groups 1 and 2 was highly significant, as shown in Figure 2.

1965 Procedure

Fifty-six grade Hereford steers, identified by neck and hip numbers, were used to study the effects of poloxalene, a nonionic surfactant, on bloat prevention. The research was divided into two parts, Experiment I and Experiment II.

Experiment I was conducted to determine if poloxalene, incorporated in grain pellets and fed free choice each day, would prevent bloat in cattle grazed on Ladino clover. Fifty-three of the 56 steers were randomly assigned into three groups, and the three remaining steers were held and used for replacement purposes. Nineteen steers were assigned to Group 1 (controls), 18 to Group 2 (poloxalene-treated), and 16 to Group 3 (penicillin-treated). After the research on Group 3 was completed, 10 steers from Group 3 were selected and placed in Group 4, the poloxalene-treated, free-grazing group. Steers in Groups 1 and 2 were grazed on the same clover pasture each grazing period. Steers in Group 3 were grazed on a separate pasture, as were steers in Group 4.

Research conducted with Groups 1, 2, 3, and 4 was divided into conditioning, treatment, and post-treatment phases. Table 1 shows the number of days in each phase for each of the four groups. During the conditioning phase, Groups 1, 2, and 3 were fed placebo pellets (containing no poloxalene) at the rate of 210 grams per animal per day. Initially, steers in Groups 1, 2, and 3 were grazed two hours twice daily beginning at 6:00 A.M. and 3:00 P.M. As the treatment phase progressed, morning and afternoon grazing times for Groups 1, 2, and 3 were gradually reduced to as little as 45 minutes because of the severity of bloat. Between grazing periods, steers in Groups 1, 2, and 3 were placed in holding lots adjacent to the clover pastures, with water, shade, and salt available.

Table 1.—Numbers of Animals Used in Each Group and Days on Experiment, 1965

	Days			Animal numbers		
Groups	Conditioning	Treatment	Post-treatment	Initial	Added during experiment	Final
1. Placebo pellets	14	69	4	19	6	8
2. Poloxalene pellets	14	69	4	18	—	15
3. Penicillin	15	17	3	16	—	15
4. Free-grazing, poloxalene treated	6	55	12	10	—	10
5. Molasses control block	4	17	—	9	—	9
6. Molasses-poloxalene block	4	17	—	9	—	9
7. Individual consumption, molasses-poloxalene blocks	4	17	—	6	—	6

Throughout the treatment phase the placebo pellets were fed free choice to Group 1 at the rate of 210 grams per animal per day, and the poloxalene-treated pellets[9] were fed free choice to Group 2 at the rate of 220 grams per animal per day (10 grams of poloxalene). Group 3 steers were administered 125 milligrams of procaine penicillin by capsule daily at 10:30 A.M. The steers in Groups 1, 2, and 3 were graded for bloat after each grazing period, and the steers in Group 4, the poloxalene-treated, free-grazing group, were graded for bloat once each day. Bloat induction potential of the clover was high for Experiment I.

Observations were made to determine the optimum time of the day to feed the poloxalene-treated pellets to Groups 1 and 2. Three feeding times were tested: (1) prior to morning grazing, (2) after morning grazing when all bloated animals had returned to normal, and (3) prior to afternoon grazing.

Steers in Group 4 were fed treated pellets free choice at the rate of 220 grams per animal per day at 7:00 A.M. daily.

When the respective treatment periods for Groups 1, 2, 3, and 4 were terminated, each group was permitted to continue to graze clover during the respective post-treatment periods in accordance with the established routine for each group. This further tested the bloat induction potential of the clover and the efficiency of the treatment(s).

Experiment II was organized following the post-treatment phase of Groups 1 and 2 to determine if cattle would lick salt-molasses blocks (30 grams poloxalene per 1 lb. of block) in sufficient amounts to control clover bloat. Bloat induction potential of the clover was not so high for Experiment II as it was for Experiment I.

Twenty-three steers from Groups 1 and 2 were randomly assigned to three groups. Nine were placed in Group 5 (controls) and nine in Group 6 (treated). Five of the 23 plus one additional steer were assigned to Group 7 to determine consumption of poloxalene-treated blocks by individual steers. Table 1 shows the number of days in the conditioning and treatment phases for the three groups. Post-treatment phases were not used because the clover abruptly stopped growing, due to climatic conditions, after the treatment phases were completed.

Two salt-molasses blocks without poloxalene (placebo) were placed in one holding lot for Group 5, and two poloxalene-treated salt-molasses blocks were placed in a separate holding lot for Group 6. Steers in Groups 5 and 6 were grazed together on the same clover pasture twice daily beginning at 6:00 A.M. and 3:00 P.M. Initially the two groups were grazed for two hours each morning and each afternoon, but the grazing periods were soon reduced to one hour during the treatment phase. Between grazing periods the steers (Groups 5 and 6) were held in their assigned holding lots. Steers in Groups 5 and 6 were graded for bloat after each grazing period, and Group 7 steers were graded for bloat once daily.

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[9] The placebo and treated pellets were supplied by Smith Kline and French Laboratories, Philadelphia, Pennsylvania.

Each of the six steers in Group 7 was placed in a separate Ladino clover pasture of approximately 0.5 acre each. One poloxalene-treated salt-molasses block was placed in each of the six clover pastures. Each steer free-grazed clover and had access to the block in his pasture at all times. All six steers had ready access to salt, steamed bone meal, and water.

Individual blocks provided each of the three groups were weighed each day to determine the average daily consumption of each block per steer in the three groups. The placebo blocks and the poloxalene-treated blocks were replaced when necessary.

1965 Results

Experiment I demonstrated that grain pellets containing 10 grams of poloxalene per 220 grams of pellets and fed daily free choice (220 grams per steer) reduced incidence and severity (Figure 3) of bloat in steers (Group 2) permitted to graze clover twice daily. Similarly treated pellets (220 grams per steer) controlled severe and lethal bloat in steers free-grazed on Ladino clover (Figure 4). Some steers in Group 1, which were fed the placebo pellets, and some steers in Group 2, which were fed the poloxalene-treated pellets, did not eat their pellets readily every day. Steers in Group 2 which did not eat sufficient quantities of the treated pellets bloated most frequently, and three of them developed lethal bloat (Figure 3).

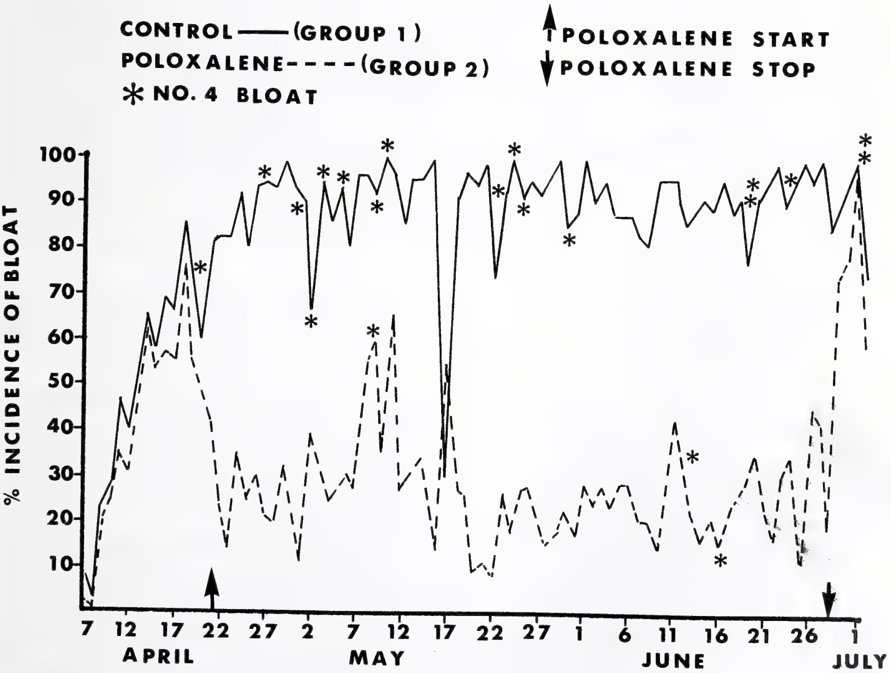

FIGURE 3.—The effects of feeding poloxalene-treated pellets on the average daily bloat incidence in cattle grazing lush Ladino clover.

Because of the high incidence and severity of bloat in the controls (Group 1, Figure 3), the morning and afternoon grazing periods, initially two hours, were reduced to 45 minutes during treatment and post-treatment phases in an attempt to maintain an adequate number of controls. Even so, 17 steers in Group 1 developed lethal bloat and it was necessary to add six steers to Group 1 (Table 1) to maintain a sufficient number of control animals.

Fourteen of the 17 steers in Group 1 and all three of the steers in Group 2 developed lethal bloat after the afternoon grazing periods during the treatment phase. This may have been due to the short interval between morning and afternoon grazing as compared with the longer interval between afternoon and morning grazing.

Only one of the three steers in Group 2 which developed lethal bloat showed signs of typical clover bloat (frothy ruminal ingesta). The other two steers had a gaseous type of bloat with no froth. It is possible these steers consumed clover too rapidly and the clover blocked the cardias, preventing eructation of gas.

Rumenotomies and artificial respirations were applied to the 21 steers which developed lethal bloat (one case occurred before the steers were randomly divided and assigned to groups) and 18 were saved. However, two of the 18 died with acute peritonitis within two weeks after treatment, and a third died approximately six weeks after treatment.

On day 40 of the experiment, placebo pellets were fed by mistake (Figure 3) to Group 2 and the poloxalene pellets were mistakenly fed the steers in Group 1 (control). This error showed how quickly poloxalene would control clover bloat in untreated cattle which had been bloating consistently for several weeks. The relatively low incidence and severity of bloat in Group 2 steers on day 40 indicated that there was some carry-over effect of poloxalene from the previous day. Control of bloat in Group 2 was quickly established on day 41 after the steers consumed the poloxalene pellets. Bloat incidence and severity in the control steers, Group 1, increased quickly after feeding of placebo pellets was resumed on day 41.

The results with Group 3 steers (penicillin-treated) demonstrated that penicillin will control clover bloat in cattle for only a brief period (Figure 4).

The 10 steers in Group 4, the free-grazing group, consumed poloxalene pellets for two days before activation of their treatment phase. These steers were selected from Group 3 because they ate the poloxalene-treated pellets readily each day. They maintained a very good fill of clover every day during the 55-day treatment phase.

Differences in grazing management did not permit comparing Group 4 with any other group. Due to the bloat-producing qualities of the clover, shown by Group 1, a control group could not be used because of the probability that all untreated control steers would have developed lethal bloat within a few days. However, the experiment with Group 4 showed that poloxalene is effective (Figure 4) in preventing severe or lethal bloat in cattle free-grazed on Ladino clover with high bloat induction potential. The post-treatment phases for Groups 1, 2, 3, and 4 showed bloat induction potential of the clover was high (Figures 3 and 4) throughout Experiment I. The effectiveness of poloxalene treatment in Groups 2 and 4 was also demonstrated. Penicillin, Group 3, had lost its effectiveness (Figure 4) before the post-treatment phase for this group was initiated.

Analysis of variance of the data from Groups 1 and 2 indicated that the differences between grazing times and treatments for both incidence and severity of bloat were significant ($P < .01$). In Group 1, the percentage incidence of bloat averaged 90.5 and the average severity score was 1.90. By comparison, the percentage incidence of bloat in Group 2, poloxalene-treated, was 27.4 and the average severity score was 0.43.

Differences in daily incidence of bloat between Groups 1 and 2 were not significant, but differences in severity relative to time of feeding the pellets were significant ($P < .01$). The study involving Groups 1 and 2, admittedly unorthodox, indicated that prior to morning grazing was the most desirable time to feed poloxalene pellets.

Experiment II showed that poloxalene-treated salt-molasses blocks (30 grams poloxalene per 1 pound of block), offered free choice, controlled incidence and severity of bloat in steers (Group 6) grazed on clover twice daily. The poloxalene-treated blocks, offered free choice, were more effective in controlling bloat in individual steers (Group 7) which were free-grazed on clover than they were when offered to steers

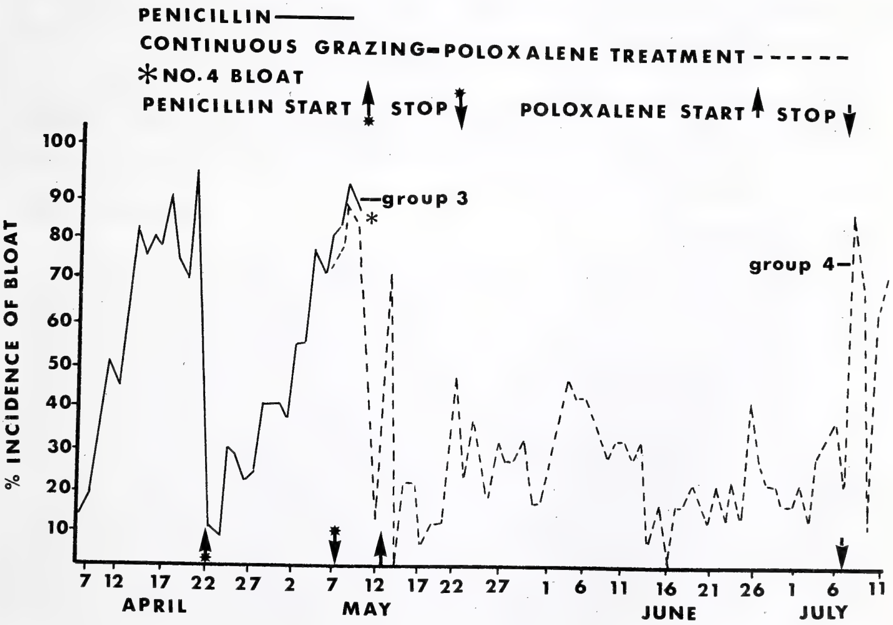

FIGURE 4.—Effects of feeding poloxalene-treated pellets on the average daily bloat incidence compared with penicillin; also the comparison of the persistency of the two treatments in cattle grazing lush Ladino clover.

managed as a group and held in drylot between clover grazing periods (Group 6).

Because of the high incidence of bloat in the control steers (Group 5) and the severity of bloat in some of these steers, it was necessary to reduce the initial morning and afternoon grazing periods for Groups 5 and 6 from two hours to one hour to prevent some steers in Group 5 from developing lethal bloat.

Groups 5 and 6 each had a total of 306 opportunities to bloat. None of the steers in Groups 5 or 6 developed lethal bloat, but there were 47 cases of number 3 bloat in the control steers (Group 5) and only five cases of number 3 bloat in the treated steers (Group 6). Group 5 had a total of 207 cases of number 1 and 2 bloat compared with a total of 65 cases of number 1 and 2 bloat in Group 6. Differences between Groups 5 and 6 for average daily incidence and severity were significant ($P < .01$).

Control Group 5 consumed an average of 1.5 pounds of placebo block per animal per day and Group 6 consumed an average of 0.9 pound of poloxalene-treated block per animal per day.[10]

Group 7 was free-grazed, and none of these steers bloated during the treatment phase. However, one steer in this group did not consume any of his block on one day of the experiment. Apparently there was a carry-over effect of the poloxalene from the preceding day in this steer. Individual consumption of the poloxalene blocks (Group 7) varied from 0 to 1.8 pounds per animal per day, and the average daily consumption of the poloxalene blocks by the six steers in Group 7 varied from 0.61 to 1.19 pounds per animal per day, or from two to almost four times the required daily amount of poloxalene (10 grams per steer) to control bloat.

Experiment II indicated that animals free-grazed on Ladino clover will consume more than the necessary amount of poloxalene to control bloat if it is provided free choice in salt-molasses blocks containing 30 grams poloxalene per pound of block.

1966 Procedure I

A field trial study using poloxalene-treated salt-molasses blocks, 30 grams per pound of block, was conducted in the spring of 1966. Four herds of cattle (a total of 144 head) and pastures provided by cattlemen near Hamburg, Louisiana, were used. Initially each herd was grazed on a separate pasture of "Nolin's Improved Louisiana White Clover," and each herd was provided treated or untreated blocks in covered troughs free choice. The treated blocks were periodically replaced with untreated blocks to determine the bloat induction potential of the clover in three of the pastures during the experiments. The blocks were provided at the approximate rate of one per four head of cattle and were weighed every day by a representative of the Louisiana Agricultural Experiment Station except for two days during the experimental period. New blocks were added to each trough after approximately 60 per cent of the initial weight had been consumed.

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[10] Treated and untreated blocks were supplied by A. E. Staley and Company, Decatur, Illinois, for the 1965 and 1966 experiments.

Each animal in each of the four herds was observed during the morning and afternoon, except for the two days previously mentioned, and incidence and severity of bloat for each animal were recorded.

Herd 1 included 60 long yearling heifers, some of which had been bred; 15 calves were born during the experimental period. Most of the heifers were Herefords, but the group included a few Shorthorns and Santa Gertrudis crosses. The pasture for this group was approximately 85 acres including about 20 acres of woods. The quantity and quality of clover available were very good throughout the trial. There was very little palatable grass in the pasture.

Herd 2 consisted of 33 mature cows, a few of them with fall calves. Most of the cows were Herefords. They were initially placed on a seven-acre pasture of excellent white clover, but within two weeks the pasture was overgrazed and no longer capable of inducing bloat. Near the end of the experimental period this group was shifted to a pasture of about 40 acres, which was predominantly Persian clover and which was adjacent to about 20 acres of woods.

Herd 3 consisted of 25 mature Hereford cows, two of which calved during the experimental period. The pasture was approximately 25 acres, included one shade tree, and consisted of a white clover-ryegrass mixture. The clover predominated early in the trial but later there was sufficient ryegrass to limit bloat induction.

Herd 4 consisted of 25 mature Hereford cows and one Shorthorn. Three cows calved during the trial and one of these was removed from the experiment because of mastitis. The pasture contained about 25 acres with one shade tree and had been newly seeded to white clover and fertilized. Clover quantity and quality were extremely good throughout the trial.

1966 Results I

Herd 1, 60 long yearling heifers, was placed on lush white clover March 19, 1966, with placebo blocks available until the afternoon of March 21, when the placebo blocks were replaced by treated blocks and control of bloat was obtained. However, an increase in bloat incidence occurred on March 23, because of a change in the grazing pattern of the herd. This made it necessary to add an additional trough with blocks. Because of the shape and size of the pasture (80 acres) it was necessary to provide four covered feed troughs with blocks to ensure opportunities for every animal to lick the blocks daily. On April 2 the heifers were penned five hours for weighing purposes, and within two hours after they were turned back to pasture, one died with number 4 bloat. Figure 5 shows the relatively low incidence of bloat for Herd 1. The increase in bloat during the two 48-hour control periods initiated on April 3 and April 24 (Figure 5) indicated the bloat induction potential of the clover.

Herd 2, composed of 33 mature cows, was placed on pasture April 2, 1966. Poloxalene controlled bloat in these cattle for about two weeks while they were grazed on seven acres of excellent white clover. On April 26 they were moved to a Persian clover pasture for a short time and treated blocks were used to control bloat.

Herd 3, composed of 25 head of mature Hereford cows, was placed on a pasture of white clover-ryegrass mixture March 22, 1966. After approximately two weeks the ryegrass became dominant. One trough with blocks was initially located close to the water trough in this pasture. During this time the cattle consumed but small quantities of the blocks and bloat incidence in the herd increased. Figure 6 shows that prevention of clover bloat was obtained after March 25, when the trough was moved to a location under a lone shade tree where the cattle congregated when resting. The incidence of bloat during the 48-hour control period initiated April 13 (Figure 6) indicated the bloat induction potential of this pasture was not comparable to that of pastures grazed by Herds 1 and 4 (Figures 5 and 7).

Herd 4, 26 mature Hereford cows, was placed on clover March 22, 1966. The pasture consisted of 25 acres of first-year clover. One trough with treated blocks was initially placed near the water trough, but after five days it was relocated under a lone shade tree in the pasture. During the first five days of this trial the cattle did not consume enough of the treated blocks to prevent severe bloat, but bloat incidence and severity were low for some unknown reason(s). However, the first control period,

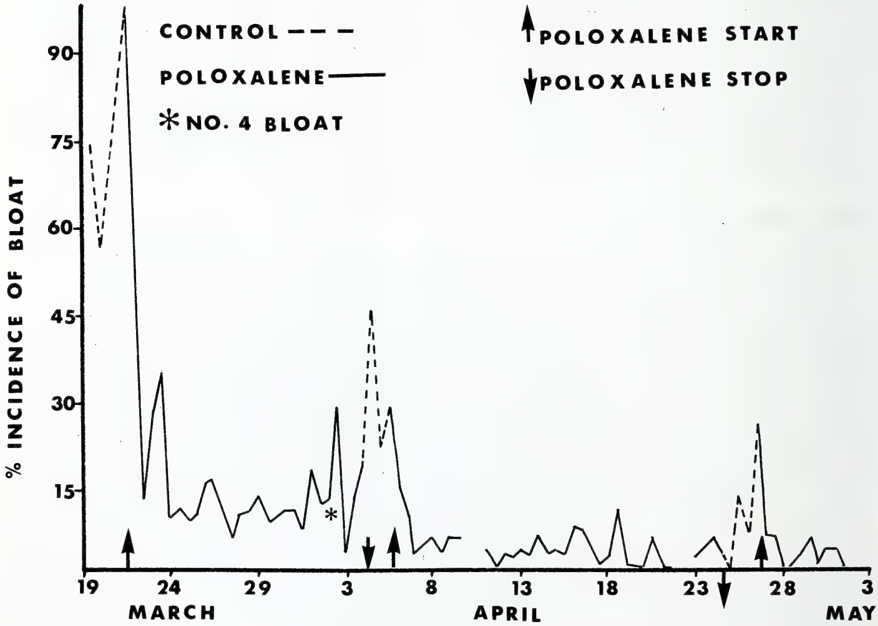

FIGURE 5.—Effects on the average daily bloat incidence of poloxalene-treated salt-molasses blocks provided cattle grazing good clover-grass pasture under range conditions.

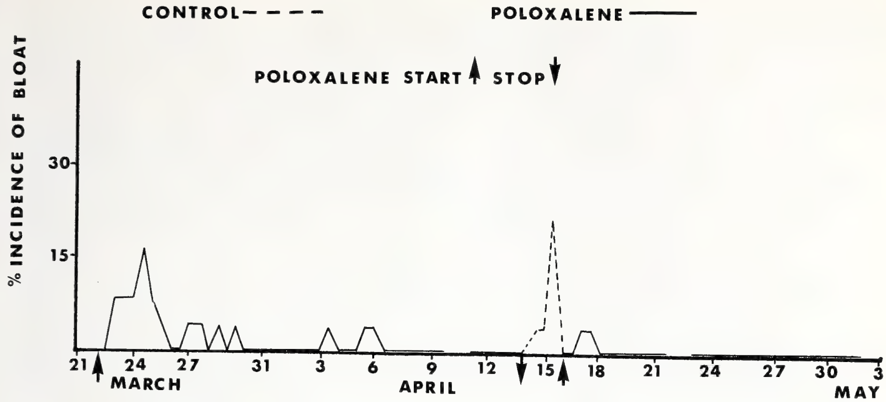

FIGURE 6.—Effects on the average daily incidence of bloat of poloxalene-treated salt-molasses blocks provided cattle grazing good grass-fair clover pasture under range conditions.

which was initiated April 12, was terminated 12 hours before the 48-hour control period was completed due to the high incidence and severity of bloat (Figure 7). During this 36-hour control period 21 cases of bloat were observed, with six being moderate to severe (numbers 2 and 3 bloat). For some unknown reason(s) the cattle consumed inadequate quantities of the treated blocks from April 15 to April 18, and bloat incidence increased. On April 18 the cattle voluntarily started to con-

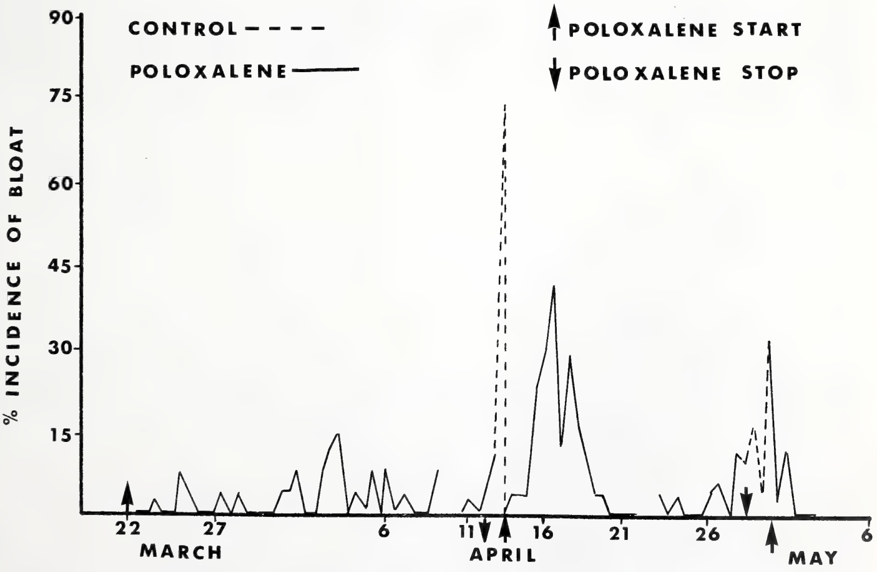

FIGURE 7.—The effects on average daily bloat incidence of poloxalene-treated salt-molasses blocks provided cattle grazing excellent clover-grass pasture under range conditions.

sume the treated blocks in sufficient quantities and prevention of bloat was again established. The relatively low bloat incidence during the second 48-hour control period, which was initiated April 27, indicated the bloat induction potential of the clover had decreased.

Table 2 shows the total cow days on poloxalene, the amount consumed by each herd, and the average daily consumption of each cow. The overall average of 0.71 pound of poloxalene-treated block per cow per day is more than twice the amount needed to prevent severe or lethal clover bloat in cattle.

Table 3 shows the body weight gains of Herds 1, 3, and 4. It also gives a comparison of average daily body weight gains per cow per day in Herds 3 and 4. Herd 3 grazed a very good ryegrass-clover pasture which was predominantly ryegrass, while Herds 1 and 4 grazed very good pastures which were predominantly clover.

Table 2.—Consumption of Salt-Molasses Blocks with Poloxalene, 1966

Herd	Cow days on poloxalene	Total consumption of blocks with poloxalene (lb.)*	Average daily consumption/cow (lb.)
Herd 1	2313	1459.6	0.63
Herd 2	750	868.0	1.16
Herd 3	975	665.1	0.68
Herd 4	946	554.2	0.59
TOTAL	4984	3546.9	0.71

*30 grams of poloxalene per pound of block.

Table 3.—Liveweight Gains While Grazing Clover, 1966

Herd	Number of animals	Days between weighings	Avg. initial weight (lb.)	Avg. final weight (lb.)	Avg. gain per day (lb.)
Herd 1	59	34	653	722	2.03*
Herd 3	25	32	984	1,022	1.19**
Herd 4	26	32	894	976	2.56***

*This disregards 15 calves dropped during the period. If their weight is added to the final weight of their dams, average daily gain becomes 2.77 lb./day.

**This disregards two calves dropped during the period.

***This disregards three calves dropped during the period.

1966 Procedure II

Thirty-five yearling Hereford steers were used to determine if *Clostridium perfringens* type E and D toxoids would prevent clover bloat in cattle which had been administered the toxoids. Group 1 consisted of 15 control steers which were not inoculated with toxoids. Group 2 consisted of 10 steers each of which was inoculated with five milliliters of type C and five milliliters of type D toxoids subcutaneously on March 11, 1966. The 10 steers in Group 3 were each inoculated with five milliliters of type C and five milliliters of type D toxoids subcutaneously on March 11 and again the morning of April 21, 1966. All steers in the three groups were grazed on the same clover plot for two hours each morning and two hours each afternoon for nine days. Each steer was observed for bloat incidence and severity after each grazing period and the data were recorded.

1966 Results II

Some of the steers in each group started to bloat three days after they were initially placed on the clover, and four days later incidence and severity of bloat in the three groups showed that the toxoids did not prevent bloat. During the experimental period of nine days there was a total of four cases of severe bloat (number 3) in Group 1 (controls), three in Group 2, and three in Group 3. However, no cases of lethal bloat (number 4) occurred in any group. The maximum per cent of steers that bloated in Groups 1, 2, and 3 during the experimental period was 60, 44, and 70, respectively. Nine days after the steers were placed on clover they were provided poloxalene-treated salt-molasses blocks free choice at the approximate rate of one block per four steers. This reduced the severity and incidence of bloat and prevented induction of severe or lethal bloat in all of the experimental steers until the clover quit growing the first week in July.

1967 Procedure

Thirty-four yearling Hereford steers were employed in an experiment to learn if *Clostridium perfringens* type D bacterin would prevent clover bloat in cattle which had been vaccinated with the bacterin. Fourteen steers were placed in Group 1, the untreated controls. Each of the 10 steers in Group 2 was inoculated subcutaneously with five milliliters of the bacterin on March 23, 1967. Each of the 10 steers in Group 3 was administered five milliliters of the bacterin subcutaneously on March 23 and again on May 20, 1967. The 34 steers were placed on clover the afternoon of May 27, 1967. The steers were grazed on the same clover pasture for periods ranging from 30 minutes to two hours each morning and afternoon for 18 days.

1967 Results

The incidence of bloat increased significantly after the first five grazing periods in all three groups of steers. However, no cases of lethal bloat occurred in any of the three groups, but there were five cases of severe bloat (number 3) in Group 1, nine in Group 2, and three in Group 3. *Clostridium perfringens* bacterin type D did not prevent the treated steers (Groups 2 and 3) from bloating. The maximum incidence of bloat in each of the three groups occurred on the last day of the experiment, May 14, 1967. Eighty per cent of the steers in Group 1 bloated, as did 95 per cent of those in Group 2 and 66 per cent of those in Group 3. Poloxalene-treated salt-molasses blocks were provided free choice from May 15, 1967, through the second week in July to control severe and lethal clover bloat in the experimental cattle. The blocks were provided at the approximate rate of one block per four steers.

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Three Methods of Finishing Steers For Slaughter

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AGRICULTURAL EXPERIMENT STATION
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One of the groups of steers finished on wheat and ryegrass pasture without supplemental feed in the experiment at the West Louisiana Experiment Station.

Three Methods of Finishing Steers For Slaughter

C. B. ROARK, H. E. HARRIS, AND J. I. FEAZEL*
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INTRODUCTION

A dependable method of efficiently finishing beef cattle for the slaughter market, under Louisiana conditions, is important to the livestock producer of this state.

During past years, most of Louisiana's beef calves have been sold as feeder calves. The majority of these were shipped out of the state, usually in the fall, and finally reached feed lots of the West and Midwest where they were finished for slaughter at heavier weights.

Selling Louisiana calves at weaning age fails to take advantage of economical gains that may be made from low-cost winter pasture. The low calf crop percentage and light weaning weights which prevail in this state put a strain on the capital investment in land, labor, and the beef cow used to produce a calf to weaning age only.

When weanling calves are sold, there is a good chance, especially when cattle numbers are high and prices are low, that the calf will leave the farm before making a profit, after paying for its share of maintaining the herd.

The beef enterprise is in competition with various crops for use of the land. This is especially evident on the more nearly level areas suitable for cultivation. For example, there is a growing increase in acreage of soybeans, a protein producing crop, which in turn is being used at an increasing rate as an additive to processed meats and other foods.

In March 1966 (see Louisiana Bulletin No. 609), a five-year study was reported on finishing steers for slaughter on green winter pasture at the West Louisiana Station. In this study wheat and ryegrass pasture produced an average annual yield of 391 pounds of beef per acre from steers, or a gain of 331 pounds per head in 172 days (November to May). Economical gains, bringing them to weights and degree of finish desired by the local markets, were made by steers grazing winter pasture without other feed. When the original study was completed, it was decided that this grazing method should be compared with two other methods of finishing steers: one in which steers would be fed while grazing comparable green forage, and one in which steers would be finished on a grain and hay ration in the dry lot. This test was conducted during the winter seasons of 1962-63 through 1965-66.

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PURPOSE OF STUDY

The purpose of this study was to make a comparison of three methods of finishing feeder calves to lightweight beef.

PROCEDURE AND RESULTS

The data used in this study were secured from 109 steers during a period of four years. The steers used in the test were produced in the Angus herd at the West Louisiana Experiment Station. The test was conducted each year for an average of 169 days (November to May). Three groups of comparable calves were selected each year.

One group was placed in the dry lot and fed a balanced ration and good-quality Bermudagrass hay (Ration 1).

A second group was given access to continuous grazing on a good wheat and ryegrass pasture while being fed a supplemental ration (Ration 2).

The third group was grazed without additional feed on wheat and ryegrass pasture comparable to that used by steers which were fed and grazed.

The comparative performance of the three groups of steers was recorded for each year (Tables 1, 2, 3, and 4). Comparisons based on the four-year average are shown in Table 5.

The first two years of this test included steers and heifers, but only steers were used in the last two years. When sold, the open heifers were bought as breeders and brought a higher price per pound than steers. For this reason, the heifers were eliminated in compiling the data. This resulted in irregular numbers of steers during the first two years.

The mixed feed used in the test was bought on bid, and the two rations were the same for each of the four years. The rations and the average prices per ton for the four years were as follows:

Ration No. 1

1,500 lbs. No. 2 yellow corn, ground
300 lbs. 41% cottonseed meal
100 lbs. wheat bran
100 lbs. blackstrap molasses
2,000 lbs., cost per ton — $64.40
Bermuda hay cost per ton — $25.00

Ration No. 2

1,700 lbs. No. 2 yellow corn, ground
300 lbs. 41% cottonseed meal
2,000 lbs.,cost per ton — $58.40

TABLE 1.—Performance of Steers, 1962-63

	Dry lot	Pasture & feed	Pasture only
Number of steers	7	13	5
Initial age (days)	369	374	400
Initial weight (lbs.)	411	413	412
Final weight (lbs.)	789	758	758
Gain per animal (lbs.)	378	345	346
Number of days on test	161	161	161
Average daily gain (lbs.)	2.34	2.14	2.15
Pounds concentrate per lb. gain	6.58	3.53	None
Pounds hay per lb. gain	2.01	None	None
Acres pasture per head	None	.52	.86
Shrink to market (lbs.)	32	34	34
Market weight (shrunk, lbs.)	757	723	724
Price received per lb. (cents)	23.28	23.52	23.52

TABLE 2.—Performance of Steers, 1963-64

	Dry lot	Pasture & feed	Pasture only
Number of steers	8	8	5
Initial age (days)	388	388	315
Initial weight (lbs.)	438	442	400
Final weight (lbs.)	819	815	708
Gain per animal (lbs.)	381	373	308
Number of days on test	165	165	165
Average daily gain (lbs.)	2.31	2.26	1.87
Pounds concentrate per lb. gain	6.12	2.90	None
Pounds hay per lb. gain	1.29	None	None
Acres pasture per head	None	.83	.61
Shrink to market (lbs.)	35	34	33
Market weight (shrunk, lbs.)	784	781	675
Price received per lb. (cents)	19.81	19.48	20.80

TABLE 3.—Performance of Steers, 1964-65

	Dry lot	Pasture & feed	Pasture only
Number of steers	10	10	10
Initial age (days)	398	359	422
Initial weight (lbs.)	491	491	492
Final weight (lbs.)	899	857	853
Gain per animal (lbs.)	408	366	361
Number of days on test	173	173	173
Average daily gain (lbs.)	2.36	2.12	2.09
Pounds concentrate per lb. gain	7.35	2.54	None
Pounds hay per lb. gain	1.75	None	None
Acres pasture per head	None	.80	.85
Shrink to market (lbs.)	50	46	58
Market weight (shrunk, lbs.)	849	811	795
Price received per lb. (cents)	23.56	23.46	23.28

TABLE 4.—Performance of Steers, 1965-66

	Dry lot	Pasture & feed	Pasture only
Number of steers	11	11	11
Initial age (days)	346	348	361
Initial weight (lbs.)	451	438	445
Final weight (lbs.)	848	807	778
Gain per animal (lbs.)	397	369	333
Number of days on test	179	179	179
Average daily gain (lbs.)	2.22	2.06	1.86
Pounds concentrate per lb. gain	7.04	3.03	None
Pounds hay per lb. gain	1.53	None	None
Acres pasture per head	None	.73	.72
Shrink to market (lbs.)	37	25	20
Market weight (shrunk, lbs.)	811	782	758
Price received per lb. (cents)	25.70	25.49	25.09

COMPARISON OF METHODS

(Four-Year Average)

The primary considerations in this study were performance of steers, feed or pasture requirements, efficiency of feed consumed, and sale prices of animals sold (Table 5).

Steer Weights

Steers were put on test at an average age of 373 days. They weighed an average of near 447 pounds. After 169 days on test, the four-year average weight of steers on full feed in the dry lot was 844 pounds per head. Steers fed on pasture weighed 805 pounds, while steers on grazing without other feed weighed 788 pounds.

Feed Consumed

Steers in the dry lot consumed 2,690 pounds of concentrate and 641 pounds of hay per head, or 19.71 pounds of concentrate and hay daily.

Steers fed on pasture consumed 1,097 pounds of concentrate, or 6.49 pounds daily. They also grazed .72 of an acre of pasture per head.

The third group of steers grazed .75 of an acre of pasture per head without other feed.

Steers fed 1,097 pounds of concentrate per head on pasture gained 21 pounds more per head than steers grazed without feed. This extra gain from feed, above that made on pasture by steers without supplemental feed, increased the receipts $4.88 per steer, but the cost of the concentrate was $31.98 per steer.

TABLE 5.—Three Methods of Finishing Steers for Slaughter, Four-Year Average

	Dry lot	Pasture & feed	Pasture only
PERFORMANCE OF STEERS:			
Number of steers	36	42	31
Initial age (days)	374	366	379
Initial weight (lbs.)	451	444	448
Final weight (lbs.)	844	805	788
Gain per animal (lbs.)	393	361	340
Number of days on test	169	169	169
Average daily gain (lbs.)	2.33	2.14	2.01
FEED CONSUMED (LBS.):			
Concentrate	2,690	1,097	None
Hay	641	None	None
Grain and hay daily	19.71	6.49	None
EFFICIENCY:			
Pounds concentrate per lb. gain	6.85	3.04	None
Pounds hay per lb. gain	1.63	None	None
Pounds conc. & hay per lb. gain	8.48	3.04	None
Acres pasture per head	None	.72	.75
SALE OF STEERS:			
Shrink to market (lbs.)	39	34	37
Market weight (shrunk, lbs.)	805	771	751
Price received per lb. (cents)	23.36	23.25	23.61

Comparative Gains of Steers

The four-year average annual gain (169 days) for steers in the dry lot was 393 pounds per head, compared with 361 pounds for steers on pasture and a supplemental ration, and 340 pounds for steers grazed without other feed. The average daily gain was 2.33 pounds for the dry lot group, 2.14 pounds for steers fed on pasture, and 2.01 pounds for steers grazed without other feed.

The group fed in the dry lot and the group fed on pasture reached their highest rate of gain during January, while steers which grazed only reached their peak in rate of gain during February (Table 6).

Feed Efficiency

The steers in the dry lot that consumed an average of 2,690 pounds of concentrate and 641 pounds of Bermudagrass hay per head, or 19.71 pounds of feed per head daily, consumed 6.85 pounds of concentrate and 1.63 pounds of hay for each pound of gain (8.48 pounds of feed per pound of gain).

Although a study of efficiency is essential, a feeding trial may show high feeding efficiency, while the costs of feed used to produce such gains may be prohibitive.

Grazed without other feed.

Fed grain ration on pasture.

Fed grain and hay in dry lot.

Sale of Steers

Each steer was sold individually at public auction, with steers from each group being sold in the same sale.

The dry lot steers shrunk 39 pounds to a net weight of 805 pounds. The four-year average price per pound for all dry lot steers was 23.36 cents.

Steers fed on pasture shrunk 34 pounds and weighed 771 pounds, bringing 23.25 cents per pound.

Steers grazed without other feed shrunk 37 pounds, weighing a net of 751 pounds. Their four-year average price was 23.61 cents.

TABLE 6.—Comparative Gains per Steer by the Month (Four-Year Average, 1962-66)

		Dry lot		Pasture & feed		Pasture only	
Month	Number days	Monthly	Daily	Monthly	Daily	Monthly	Daily
		-------------		Pounds of gain		-------------	
Dec.	27	42	1.56	32	1.19	41	1.52
Jan.	31	94	3.03	92	2.97	74	2.39
Feb.	28	73	2.61	76	2.71	68	2.43
March	31	75	2.39	66	2.13	60	1.94
April	30	60	2.00	63	2.10	69	2.30
May	22	49	2.23	32	1.50	28	1.27
Avg. or Total	169	393	2.33	361	2.14	340	2.01

Costs and Returns per Steer

The gross receipt for the dry lot steers was $188.05 per head. The four-year average annual costs were $100.41 for the calf at the beginning of the test, $9.40 for sales commission, $86.75 for concentrate, $8.01 for hay, and $7.61 for feeding labor, which resulted in a total cost of $212.18. When this was deducted from $188.05 (total sales receipt per steer), the result was a loss of $24.13 per head.

The gross receipt for steers fed on pasture was $179.26 per head. The four-year average annual costs were $98.81 for the calf at the beginning of the test, $8.96 for sales commission, $31.98 for concentrate, $28.48 for pasture, and $7.61 for feeding labor, which resulted in a total cost of $175.84. When this was deducted from $179.26 (total sales receipt per steer), the return was $3.42 per head.

The gross receipt for steers grazed only was $177.31 per head. The four-year average annual costs were $100.81 for the calf at the beginning of the test, $8.87 for sales commission, and $30.15 for pasture, which resulted in a total cost of $139.83. When this was deducted from $177.31 (sales receipt per steer), the return was $37.48 per head.

All pasture costs were charged to winter grazing and no credit was given to value of grazing that followed sale of these steers.

In this study, no consideration was given to return to capital. Neither was allowance made for possible reduction in costs of pasture as a result of government payments for lime, seed, and fertilizer.

TABLE 7.—Costs and Returns per Steer, Four-Year Average

	Dry lot	Pasture & feed	Pasture only
SALE OF STEERS:			
Number of steers	36	42	31
Market weight (shrunk, lbs.)	805	771	751
Price received per lb. (cents)	23.36	23.25	23.61
Receipts per steer (gross)	$188.05	$179.26	$177.31
COSTS:			
Calf	$100.41	$ 98.81	$100.81
Sales commission	9.40	8.96	8.87
Concentrate	86.75	31.98	None
Hay	8.01	None	None
Pasture	None	28.48	30.15
Labor	7.61	7.61	None
Total costs	$212.18	$175.84	$139.83
RETURNS	– $ 24.13	$ 3.42	$ 37.48

SUMMARY

An experiment was conducted during the four-year period from 1962-63 through 1965-66 to compare three methods of finishing steers for slaughter.

One method consisted of feeding steers a fattening ration and grass hay in the dry lot. In another method, steers were fed a supplemental ration while grazing wheat and ryegrass pasture. A third method consisted of finishing steers on wheat and ryegrass pasture without other feed.

One hundred and nine Angus steers averaging 373 days of age and weighing an average of 447 pounds per head when put on test were used during the four-year period. Each year, before being placed on test, animals were graded and divided into three comparable groups.

Steers on full feed in the dry lot gained 393 pounds per head during an average of 169 days, or 2.33 pounds per day. Steers fed while on pasture gained 361 pounds per head, or 2.14 pounds daily. The third group, grazed without supplemental feed, gained 340 pounds per steer, or 2.01 pounds daily.

The four-year average price received per pound, when sold singly at the same public auction, was 23.36 cents for steers fed grain in the dry lot, 23.25 cents for steers fed a supplement on pasture, and 23.61 cents for steers fattened on wheat and ryegrass pasture without other feed.

Steers fattened by the dry lot method performed satisfactorily but resulted in a financial loss each year ranging from $14.77 to $40.89 per steer, or a four-year average annual loss of $24.13 per head, because of the high cost of feed, which was $64.40 per ton in this study.

Using the second method (steers fed while grazing pasture) gave a four-year average return of only $3.42 per head because of the high feed cost and the relatively small response obtained by supplemental feeding on these pastures.

The third method (steers finished for slaughter by grazing wheat and ryegrass without other feed) resulted in returns above costs each year ranging from a low of $28.57 to a high of $44.11, or a four-year average return of $37.48 per head.

Results of this study suggest that finishing steers on wheat and ryegrass pasture without supplemental feed offers the best chance for economical returns for animals acceptable at the local market, as judged by prices paid.

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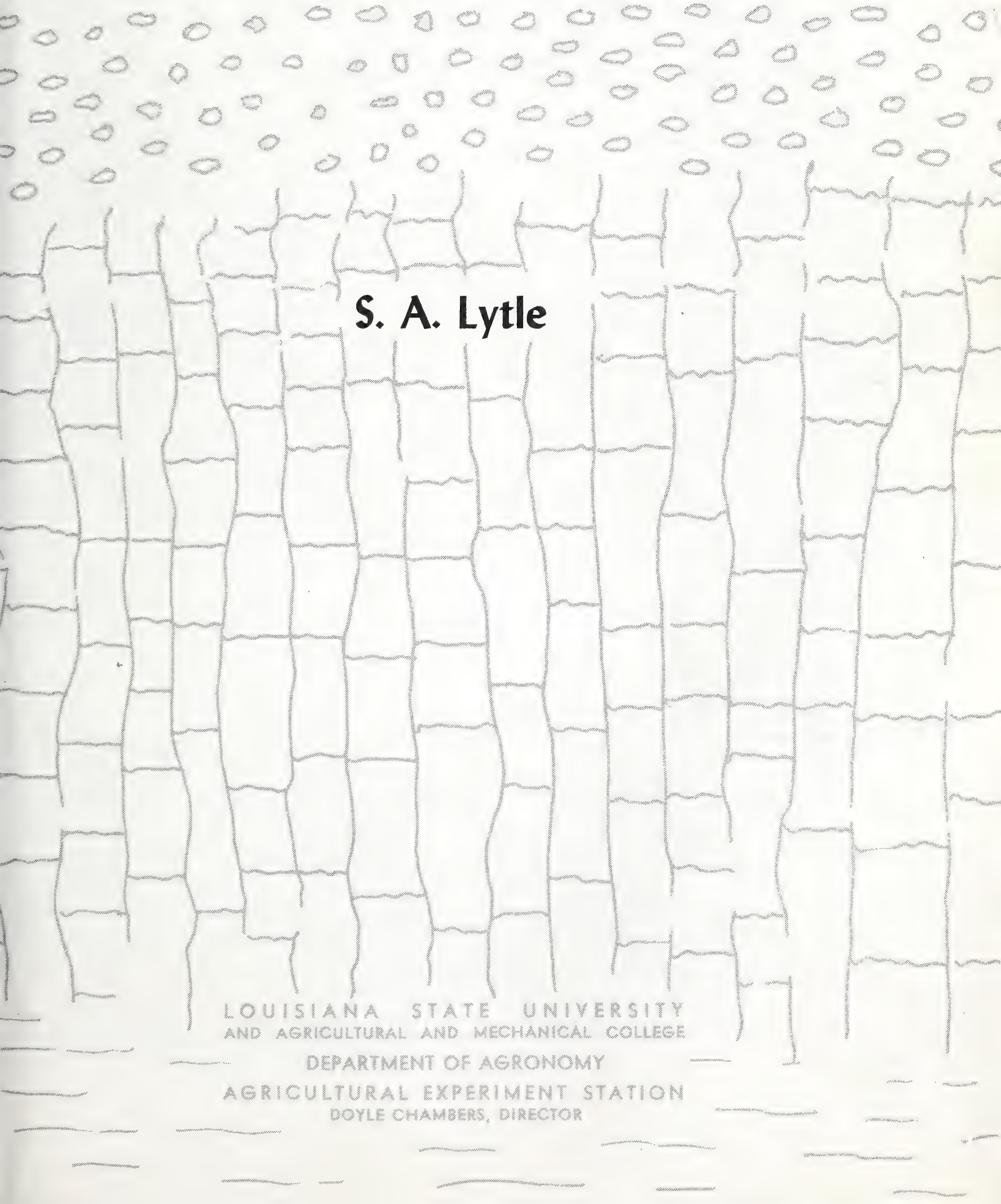
The Morphological Characteristics and Relief Relationships of Representative Soils in Louisiana



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The Morphological Characteristics And Relief Relationships Of Representative Soils in Louisiana

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S. A. LYTLE[1]

Those physical properties of soils that can be readily observed or easily measured occur in many combinations that contribute to the morphology, or the form and shape, of different soils. The morphological characteristics include the color, texture, structure, consistence, thickness, and arrangement of the various soil layers in the soil profiles.

Color is a most obvious physical characteristic of soils. Red, brown, and yellow colors are commonly associated with aerated, oxidized, well-drained, and intensely weathered soils on moderately sloping to hilly areas. Yellow soils generally occur on sites that are more moist than those of the red and brown soils. Some red and reddish-brown soils have colors that are inherited from their parent material. Gray soils have developed on nearly level slopes and in depressions under present or former conditions of a high water table and poor aeration, which has resulted in intense reduction of iron and manganese compounds. Some soil horizons are gray because excessive leaching has removed brown and red iron stainings and coatings from gray sand grains. The mottled or mixed brown and gray colors are due to alternate long periods of dryness, aeration, and oxidation, and long periods of wetness, poor aeration, and reduction. The color of surface soils is commonly used to estimate the relative contents of organic matter, the darker-colored surface soils generally containing more organic matter than the lighter-colored surface soils. Black, very dark brown, and dark gray colors are indicative of present or former conditions of very poor soil drainage and shallow inundation, site features that are favorable for the accumulation and preservation of considerable amounts of organic materials.

Soil texture refers to the fineness or coarseness of the mineral particles of a soil—the relative proportion of sand, silt, and clay. Sand particles are relatively large in size, with little exposed surface. Sand plays an almost negligible part in soil reactions, but it is important in the movement of water and air. Silt particles have some slight chemical activity, but their importance in soils is due to a high capacity to hold moisture that is available to plants. Clay particles having an extremely large exposed surface are high in total water-holding capacity. Clays serve as a storage reservoir for nutrients and water.

Structure refers to the size, shape, and strength of the natural aggregates of soil particles. Structure improves aeration and aids in the movement of water in the soil. Many soils with clay texture have either a strong, subangular blocky structure or a strong, prismatic structure. Sands lack structure and are referred to as single grain. Most silt loam and fine sandy loam surface soils have a granular structure. Many silty clay loam subsoils have a subangular blocky structure.

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Consistence refers to that property of soil material that is expressed by the degree of cohesion and adhesion, or by the resistance to deformation or rupture. Consistence varies with texture and with organic matter and moisture contents. It is measured by the amount of pressure necessary to crush moist soil material between the thumb and forefinger. Sands require no pressure and their consistence is loose; silt loams and very fine sandy loams crush easily under gentle to moderate pressure and are friable; silty clay loam material crushes under moderate pressure and the consistence is firm; strong pressure is required to crush clayey material and the consistence is very firm. Other consistence terms are used for dry soil or wet soil.

Thickness of soil layers and their arrangement in the soil profile are two of the criteria used in placing soils into different soil series. For example, soils having loamy sand upper horizons that are 50 inches thick over sandy clay loam, and soils having loamy sand upper horizons that are 12 inches thick over sandy clay loam are separated into two different soil series.

Relief, or the collective elevations or inequalities of a land surface, has an important influence on the physical properties of soils. The relief, or slope of the soil surface, influences the formation of soils through the effect on drainage, runoff, and erosion. The four broad relief positions which are generally recognized are as follows:

1. **Normal relief.** This includes the moderately sloping soils with medium runoff. Normal erosion removes material as the soil profile deepens through soil formation. Typically, the permeable soils having normal relief are well oxidized and brown or red.

2. **Subnormal relief.** This position includes the nearly level and gently sloping soil areas with slow to very slow runoff and slight erosion. The areas are generally influenced by a ground water table or a perched water table that fluctuates within the soil seasonally, producing mottlings of brown colors due to oxidation and gray colors due to the reduction of iron and manganese compounds. Gently sloping permeable soils that lie above the influence of a water table are usually yellow or brown.

3. **Excessive relief**. This relief position includes the strongly sloping knolls and hills having excessive runoff and very limited percolation of water through the soils. This results in local climatic conditions that are more arid than the normal climate of the general area. The medium-textured and fine-textured soils in these areas are highly susceptible to erosion where they are not protected by a cover of vegetation. Limited percolation of water through the soil results in very slow development of soil profiles on the steeper slopes. The soils are typically well drained, aerated, and red or brown.

4. **Flat or concave relief.** This includes flats having very slow runoff and shallow depressions that are ponded during wet seasons. Many of the areas receive runoff and sediments from adjacent slopes and from stream overflow. The local soil climate is considerably more humid than normal. A ground water table or a perched water table is at or near the soil surface during wet seasons, and the soils are gray and poorly drained. Organic matter commonly accumulates in the depressions or ponded areas, and the soils have dark gray or black surface layers.

Soil Horizons

Soils are made up of layers, or horizons, roughly parallel with the soil surface. Each horizon has characteristics produced by soil forming processes. A vertical section of a soil exposes the different soil layers, or horizons, that make up a soil profile – all the genetic soil horizons, the natural organic layers on the surface, and the parent material or other layers that lie below the zone of major biological activity. A soil horizon is usually differentiated from adjacent horizons on the basis of observable or easily measured characteristics such as color, texture, structure, and consistence.

In general descriptions of soils, it is common practice to use the terms surface soil (A horizon), subsoil (B horizon), and substratum (C horizon). Solum is a general term used for the combined surface soil and subsoil layers (A and B).

More specific terms are necessary for detailed descriptions of soil profiles. The capital letter symbols O, A, B, C, and R are used to designate the different soil layers. Subdivisions of soil horizons are indicated by arabic numbers and lower case letters after the capital letter symbols as follows: O_1, O_2, A_1, A_2, A_{2g}, A_p, A_3, A_x, B_1, B_{2t}, B_{2g}, B_3, B_{3g}, B_x, C, C_g, C_x.

Surface soil layers or horizons are designated in detailed soil profile descriptions by the following defined symbols:

O_1 horizon – fresh or little-altered organic materials at the soil surface.

O_2 horizon – mostly decomposed organic materials.

A_1 horizon – mixed organic matter and mineral soil that has formed or is forming at or near the soil surface.

A_2 horizon – a mineral soil which through leaching has lost clay, iron, or aluminum. Has a concentration of resistant minerals such as quartz in sand and silt sizes.

A_{2g} horizon – a strongly gleyed A_2 horizon, dominantly gray due to reduction of iron compounds. Typically lighter in color than A_1.

A_p horizon – a surface horizon which has been disturbed or mixed as by tillage implements.

A_3 horizon – a layer transitional between A and B, but dominated by characteristics of the A.

A_x horizon – a fragipan horizon of loamy texture which is firm and brittle when moist.

The soil layers commonly referred to as the subsoil are separated into horizons in making detailed soil profile descriptions. These horizons are identified by the following defined symbols:

B_1 horizon — a transitional layer between A and B, but dominated by properties of the B.

B_{2t} horizon — the layer of maximum accumulation of silicate clay, iron, aluminum, or humus, or any combination of these materials that have concentrated by leaching from above horizons or that have changed in place without leaching from above. Commonly identified as containing more clay than the A and C horizons, and in having a darker color and stronger blocky or prismatic structure than the C horizon.

B_{2g} horizon — a strongly gleyed B_2 horizon, dominated by gray colors due to intense reduction of iron.

B_3 horizon — a transitional horizon between B and C, but dominated by characteristics of the B.

B_{3g} horizon — dominantly gray, strongly gleyed B_3.

B_x horizon — a fragipan horizon having a loam or silty clay loam texture and moderate, blocky structure that is firm and brittle when moist.

Soil layers commonly referred to as substrata are designated in detailed soil profile descriptions by the following defined symbols:

C horizon — a mineral soil horizon that lies outside the zone of major biological activity, relatively little affected by soil forming processes; either like or unlike the material from which the solum has formed.

C_g horizon — dominantly gray, strongly gleyed C horizon.

C_x horizon — a fragipan horizon; usually has a loamy texture; firm and brittle when moist.

R horizon — unweathered rock underlying the soil profile.

Combinations or mixtures of two soil horizons are of common occurrence in soil profiles. The following defined symbols are used for these soil horizons:

AC horizon — a horizon transitional between A and C and having properties of both A and C.

A and B horizon — a mixed horizon containing more than 50 per cent A.

B and A horizon — a mixed horizon containing more than 50 per cent B.

B_x and A_x horizon — a mixture of fragipan horizons, usually identified by tongues of gray silty A_{2x} extending into a brown or mottled silt loam or silty clay loam B_x horizon.

The Fragipan Horizon

The fragipan is an important morphological characteristic of several soil series in Louisiana. This is a dense, firm layer that lies within or below the subsoil. The texture is very fine sandy loam, silt loam, or silty

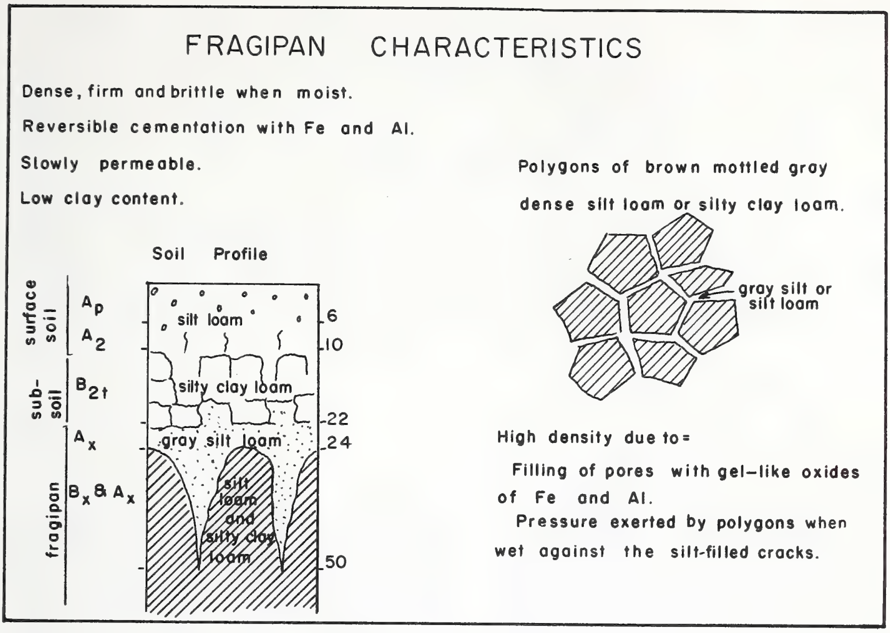

FRAGIPAN CHARACTERISTICS
Dense, firm and brittle when moist.
Reversible cementation with Fe and Al.
Slowly permeable.
Low clay content.
Soil Profile
surface soil
sub-soil
fragipan
Ap
A2
B2t
Ax
Bx & Ax
silt loam
silty clay loam
gray silt loam
silt loam and silty clay loam
6
10
22
24
50
Polygons of brown mottled gray dense silt loam or silty clay loam.
gray silt or silt loam
High density due to =
Filling of pores with gel-like oxides of Fe and Al.
Pressure exerted by polygons when wet against the silt-filled cracks.

Figure I

Explanation of symbols used in Figure 1:

1. **Black dot symbols—massive, firm silt or silt loam.**
2. **Numbers 6, 10, 22, etc. — depth in inches.**
3. **Irregularly shaped rounded figures—granular structure.**
4. **Wavy vertical lines—massive structure.**
5. **Irregularly shaped squares and rectangles—blocky or prismatic structure.**
6. **Strength of structure is indicated by the amount of the profile sketch that is covered by the symbols.**

clay loam. The fragipan is brittle when moist and hard when dry. It is slowly permeable to moisture and plant roots. The color is brown or mottled brown and gray, usually with cracks or fracture planes filled with gray silt or silt loam. The characteristics of a fragipan are illustrated in Figure 1.

There is much speculation about the genesis of fragipans. One theory of fragipan formation is that in an early stage of development, pores of the soil layer were gradually filled or plugged with gel-like oxides of iron and aluminum, and the bulk density was increased. The soil material in which the fragipan was formed originally contained enough clay to expand and shrink upon wetting and drying, thus forming lines of weakness or cracks and a polygonal structure. The cracks between polygons were filled with silt or silt loam that washed down from the upper soil layers. Upon wetting, the polygons expanded against the silt-filled cracks. After a great number of seasonal repetitions of the processes of crack filling and expansion, the resulting horizon is one of dense polygons, or a fragipan that has a higher bulk density than the upper soil layers. The fragipan represents an advanced stage of soil development in which much of the clay has been removed from the subsoil and from the fragipan.

Soil Formation

The morphology of soils in Louisiana is the result of interactions between climate, living organisms, and parent material, as conditioned by time and relief. Since the humid climate of Louisiana is essentially uniform, differences in the physical properties of soils that can be related to climate are restricted to basins or depressions that have a local superhumid climate, and to excessive slopes that have a local sub-humid or semi-arid climate.

Most of Louisiana has a forest cover of coniferous and deciduous trees. This is reflected in the forested soils of the hills that have thin organo-mineral surface soils that contain low amounts of organic matter. The Coastal Prairies of southwestern Louisiana had an original cover of tall prairie grasses. Soils that have developed in the Coastal Prairies have a deeper distribution of organic matter than the soils of forested areas.

The influences of relief and slope on the physical properties are a distinguishing soil feature throughout the state. The brown, red, and yellow, aerated, oxidized, well-drained soils occupy the slopes and hills, where they lie well above the influences of a ground water table or a perched water table. However, there are areas of gray and mottled soils in the hills that have developed in marine sediments and stream deposits of Tertiary age. These gray soils have been raised to their present high elevations through the action of geological forces. Most of the gray soils in Louisiana occupy areas of low relief on level or nearly level sites or occur in depressions where dainage through the soil is severely retarded by a high water table or a perched water table. Under these wet conditions, the soil air is replaced by water, and the compounds of iron and manganese are reduced. Good examples of perched water tables are those that lie above the fragipan layers in some soils of the Loessial Hills and Mississippi Terraces. These dense fragipans severely retard the downward movement of water and restrict the development of plant roots. During extremely wet seasons the soil layers above the fragipan contain so much excess water that periods of wetness of the soil are prolonged. Periods of soil dryness are prolonged in soils having fragipans, since the dense fragipan horizon severely restricts the upward movement of water in the soil.

Differences in parent material are also responsible for differences in the morphological characteristics of many soils. The major parent materials are: (1) the unconsolidated, reworked sands, sandy clays, and clays of the Coastal Plain soils; (2) the silty sediments of eolian and alluvial origin of the Loessial Hills, Mississippi Terraces, and the Coastal Prairies; (3) the sands, silts, and clays of the Flatwoods; (4) the sandy, silty, and clayey alluvial sediments of the Mississippi, Red, and Ouachita rivers; and (5) the very young peats, mucks, and clays of the Coastal Marshlands.

Time or age of soils generally determines the degree of soil horizon differentiation. Soils differing in age and in soil profile development have very different morphological characteristics. The age of soils in Louisiana ranges from those very young organic deposits and clayey sediments of the Coastal Marshlands that have not had time to develop genetic horizons and recent alluvial soils that have weakly developed horizons, to the extremely weathered and leached, oxidized soils of the Coastal Plain that have strongly developed horizons. However, associated with areas of the older, strongly developed soils are other soils having weakly developed profiles that are due to the nature of the parent material. Examples of older sediments with little soil profile development are sands containing very little clay, and silts on rolling and hilly areas of excessive relief.

Soil Characteristics and Relief Relationships

The following is a discussion of the morphological characteristics of the soils that are representative of each of the six General Soil Areas in Louisiana. The General Soil Areas are shown on the map on pages 12-13. They are (1) Coastal Marshlands, (2) Recent Alluvium, (3) Coastal Prairies, (4) Flatwoods, (5) Loessial Hills and Mississippi Terraces, and (6) Coastal Plain. The landscape positions and relief relationships for the predominant soils in each General Soil Area are shown in Figures 2-11.

Coastal Marshlands

Approximately 4,824,960 acres

The dominant morphological characteristics of this area are the dark brown and black colors of the organic soils and of mineral soils containing high amounts of organic matter, and the gray colors that are due to water-logged, reduced soil conditions. These wet lands lying along the Gulf of Mexico in southern Louisiana include approximately five million acres of peats, mucks, and clays of the coastal marshlands and the associated swamps. Elevations of the area range from sea level to less than five feet. Black and dark gray clays containing considerable amounts of organic matter lie along the shore of the Gulf. Clays also occur on low natural levees along bayous that flow into and across the marshes. The brown peats and black mucks contain from 30 per cent to more than 85 per cent organic matter. They occupy broad, level, and shallow concave areas. The organic materials of the peats and mucks range in thickness from two feet to more than 12 feet, over dark gray and gray clays. The mucks are highly decomposed, finely divided, and they have a granular structure when dry. The peats are fibrous and undecomposed, and the plant materials are easily identified. Parts of the area are inundated by the normal daily tides of 12 to 18 inches; additional parts are flooded by tides resulting from tropical storms.

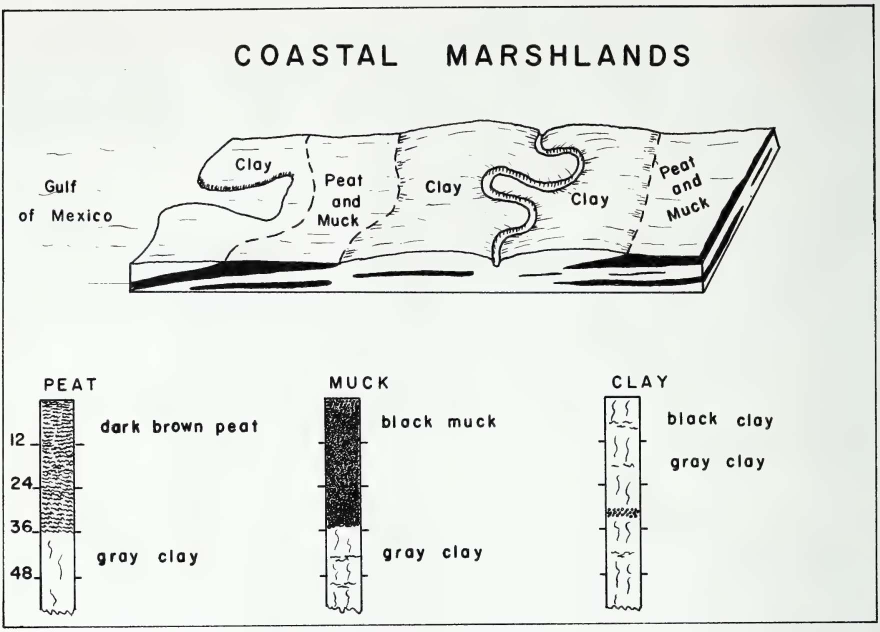


Figure 2

Explanation of symbols used in soil profile sketches in Figure 2:

1. **Wavy horizontal lines—fibrous peat.**
2. **Small oval and round figures—muck.**
3. **Wavy vertical lines—massive clay.**
4. **Numbers 12, 24, 36, etc.—depth in inches.**

Mississippi River Alluvial Soils
Approximately 4,405,120 acres

The dominant soil series representative of this area are Commerce, Mhoon, and Sharkey. The nearly level to undulating Commerce soils are on low natural levees that represent the highest elevations of the flood plain. Sharkey soils occupy level areas and depressions of the backswamps at low elevations. Mhoon soils are in broad, level areas lying between the Commerce and Sharkey soils. The dark gray or dark brown surface layers of the Mhoon and Sharkey soils are due to their moderate contents of organic matter. The brown surface layers of the Commerce soil are the result of better aeration and oxidation of soil material because of the slightly higher elevations. The gray-colored subsoils and substrata of all of these soils are due to a high water table and reduced conditions. Commerce and Mhoon soils are friable silt loams and silty clay loams. The Sharkey soil is clayey throughout, has a moderate to strong, blocky or subangular blocky structure, and a very firm consistence when moist. Commerce and Mhoon soils have weak to moderate, subangular blocky structure.

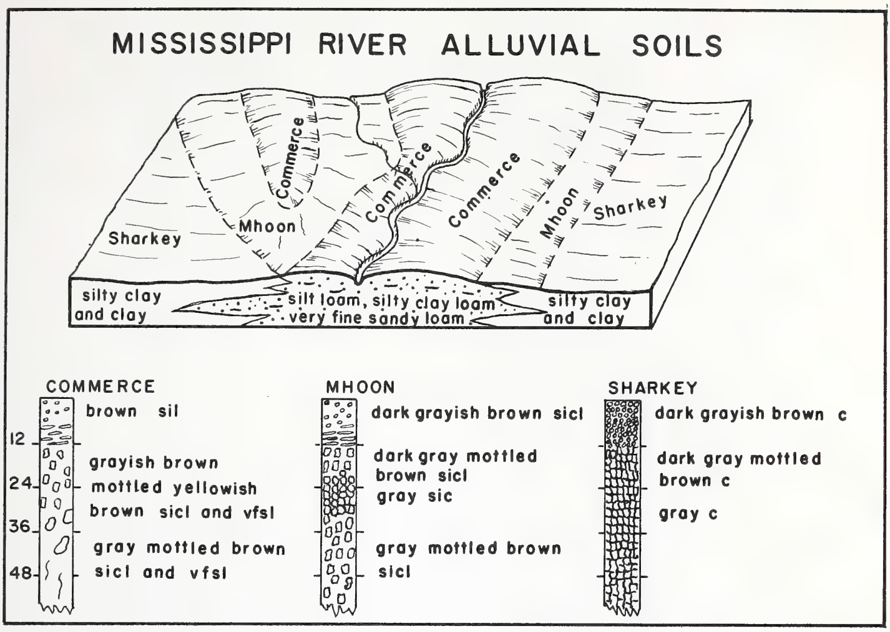

MISSISSIPPI RIVER ALLUVIAL SOILS
Sharkey
Mhoon
Commerce
Commerce
Commerce
Mhoon
Sharkey
silty clay and clay
silt loam, silty clay loam very fine sandy loam
silty clay and clay
COMMERCE
brown sil
grayish brown mottled yellowish brown sicl and vfsl
gray mottled brown sicl and vfsl
12
24
36
48
MHOON
dark grayish brown sicl
dark gray mottled brown sicl
gray sic
gray mottled brown sicl
SHARKEY
dark grayish brown c
dark gray mottled brown c
gray c

Figure 3

Explanation of symbols used in profile sketches, Figures 3 through 11:

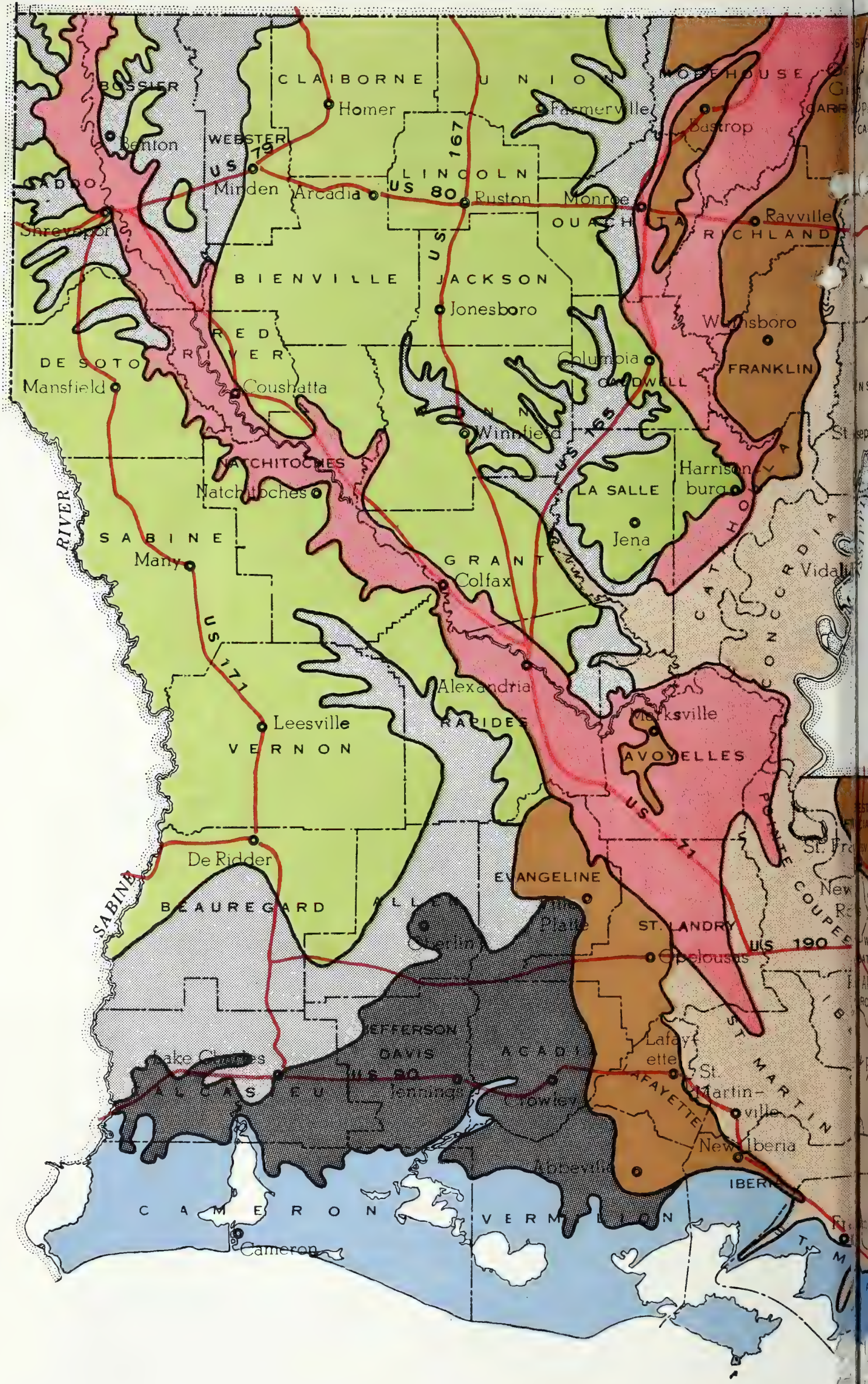
1. Circles and irregularly shaped rounded symbols—granular structure.
2. Horizontally elongated oval figures—platy structure.
3. Irregularly shaped squares and rectangles—blocky and prismatic structure.
4. Wavy vertical lines—massive soil material.
5. Diagonal lines—fragipan layer.
6. Irregularly rounded symbols and horizontal figures—ironstone gravels and ironstone lenses.
7. Profile sketch without symbols—structureless sands.
8. Degree or strength of structure is indicated by the amount of the profile sketch that is covered by the symbols.
9. Numbers 12, 24, 36, etc.—depth in inches.
10. Abbreviations:

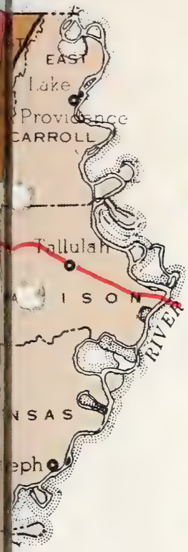
l	loam		
sil	silt loam	fsl	fine sandy loam
sicl	silty clay loam	sl	sandy loam
sic	silty clay	ls	loamy sand
cl	clay loam	lfs	loamy fine sand
c	clay	scl	sandy clay loam
vfsl	very fine sandy loam	sc	sandy clay

Alluvial Soils of the Red and Ouachita Rivers

Approximately 4,104,320 acres

The major soil series of these young alluvial soils are Norwood, Yahola, Moreland, and Perry. The well-drained, nearly level and undulating Norwood and Yahola soils occupy low natural levees at the highest

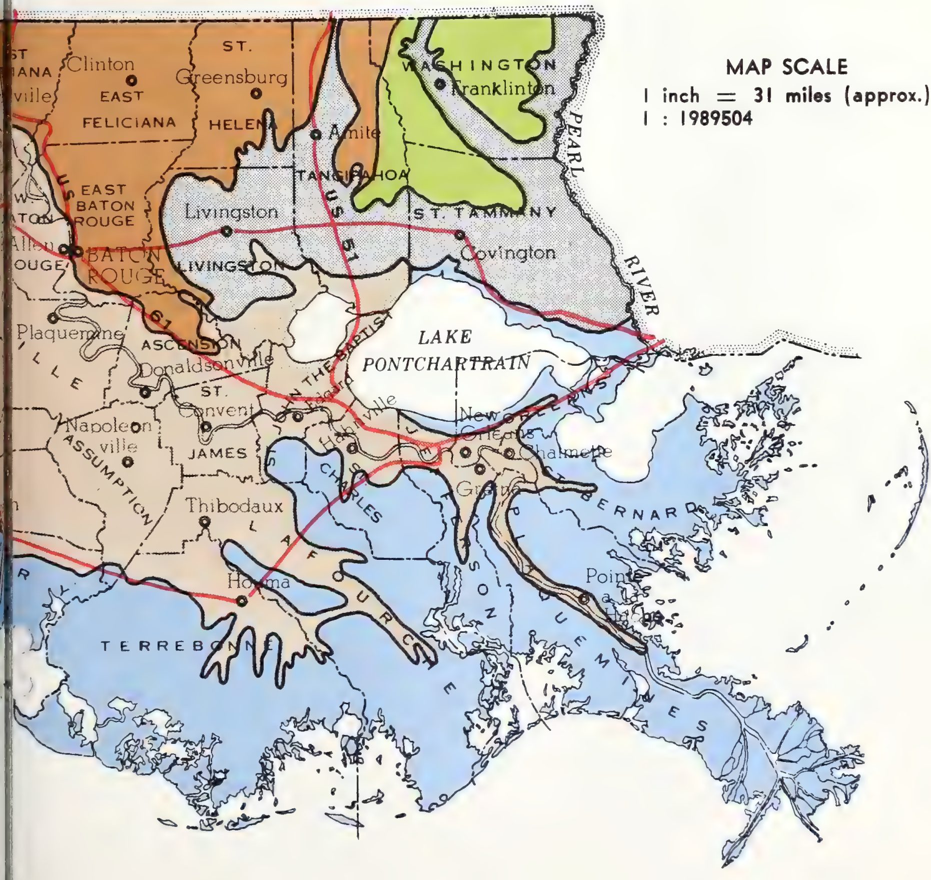

CLAIBORNE
Homer
UNION
Farmerville
MOREHOUSE
Bastrop
BOSSIER
Benton
WEBSTER
US 79
Minden
CADDO
Shreveport
Arcadia
LINCOLN
US 167
US 80
Ruston
Monroe
OUACHITA
Rayville
RICHLAND
BIENVILLE
JACKSON
Jonesboro
Winnsboro
FRANKLIN
RED RIVER
DE SOTO
Mansfield
Coushatta
Columbia
CALDWELL
WINN
Winnfield
US 165
NATCHITOCHES
Natchitoches
LA SALLE
Jena
Harrisonburg
CATAHOULA
CONCORDIA
Vidalia
RIVER
SABINE
Many
GRANT
Colfax
US 171
Alexandria
RAPIDES
Leesville
VERNON
Marksville
AVOYELLES
US 71
De Ridder
SABINE
BEAUREGARD
ALLEN
Oberlin
EVANGELINE
Ville Platte
ST. LANDRY
Opelousas
US 190
POINTE COUPEE
JEFFERSON DAVIS
ACADIA
Lake Charles
CALCASIEU
US 90
Jennings
Crowley
Lafayette
LAFAYETTE
St. Martinville
ST. MARTIN
New Iberia
IBERIA
Abbeville
CAMERON
Cameron
VERMILION



GENERAL SOIL AREAS IN LOUISIANA

- 🟩 GENTLY SLOPING TO HILLY COASTAL PLAIN—Shubuta, Ruston, Bowie, Lucy, Troup, Kirvin, Nacogdoches, Susquehanna, Ora, Sawyer, Boswell, etc., with Cahaba, Prentiss, Stough
- 🟧 LOESSIAL HILLS AND MISSISSIPPI TERRACES—Olivier, Loring, Memphis, Providence, Lexington, Calhoun, Jeanerette, etc., with Cascilla, Waverly, Collins
- ░ FLATWOODS AREAS—Caddo, Beauregard, Acadia, Frost, Calhoun, Zachary, Wrightsville, etc., with Bibb, Waverly
- ▓ COASTAL PRAIRIES—Crowley, Midland, with Beaumont, Bernard, Acadia
- ⬜ RECENT ALLUVIUM (MISSISSIPPI RIVER ALLUVIAL SOILS)—Sharkey, Mhoon, Commerce, Tunica, etc., with Cypremort, Dundee, Baldwin, Iberia, Jeanerette
- 🟥 RECENT ALLUVIUM (ALLUVIAL SOILS OF THE RED AND OUACHITA RIVERS)—Moreland, Norwood, Yahola, Perry, Portland, etc., with Gallion, Hebert, Pulaski
- 🟦 COASTAL MARSHLANDS—Marsh Peats, Mucks, Clays, and Harris, with Swamp Peats, Mucks, and Clays

Compiled by S. A. Lytle, Associate Professor, Department of Agronomy, Louisiana Agricultural Experiment Station, Baton Rouge, La. OCTOBER 1968



MAP SCALE
1 inch = 31 miles (approx.)
1 : 1989504

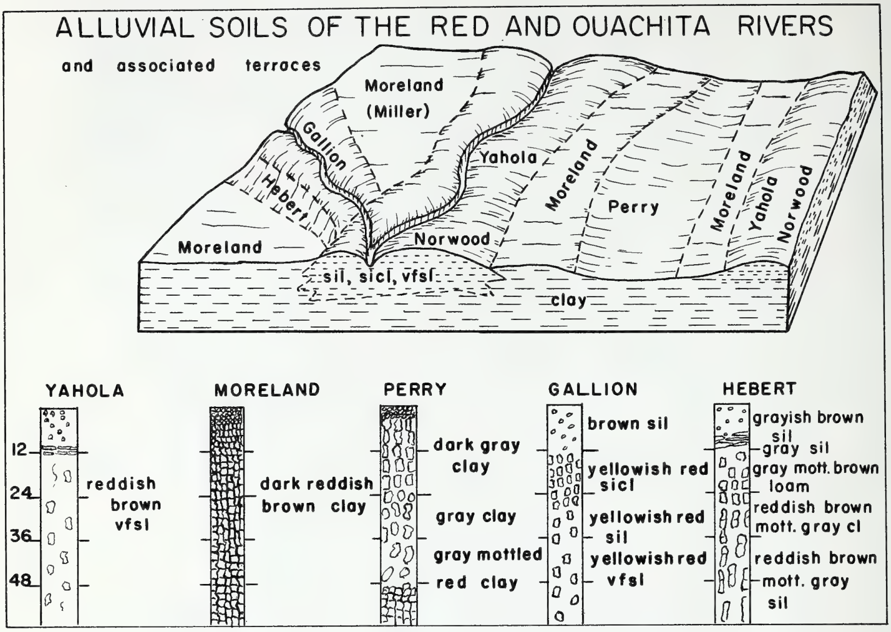


Figure 4

(See Figure 3 for explanation of symbols.)

elevations of the flood plains. The Perry soil is in flats and depressions of the backswamp areas. Level areas of Moreland soils typically occur between the level and nearly level natural levees and the backswamps. The reddish-brown color of the Norwood, Yahola, and Moreland soils is a characteristic of the geological sediments of Permian age that lie on the eastern slopes of the Rocky Mountains. Sediments from these Permian Red Bed deposits were carried into Louisiana by the Red River and by older courses of the Arkansas River, which include Bayou Bartholomew, Ouachita River, Bayou Bon Idee, and Bayou Lafourche. Perry soil has a thin, dark gray surface layer containing considerable amounts of organic matter, overlying gray, poorly aerated, reduced soil layers. The friable Norwood and Yahola soils are aerated, oxidized, and well drained. Structure is weak to moderate, subangular blocky. Norwood soil is dominated by silty textures, while the Yahola soil is more sandy. Moreland and Perry soils are clayey throughout, and they have moderate to strong structure, and a very firm consistence when moist.

The well-drained Gallion soil and the somewhat poorly drained Hebert soil are on level and nearly level terraces bordering the flood plains. Gallion soil has an aerated, oxidized, yellowish-red subsoil. The subsoil of the Hebert soil is mottled brown and gray due to fluctuations in the height of the water table.

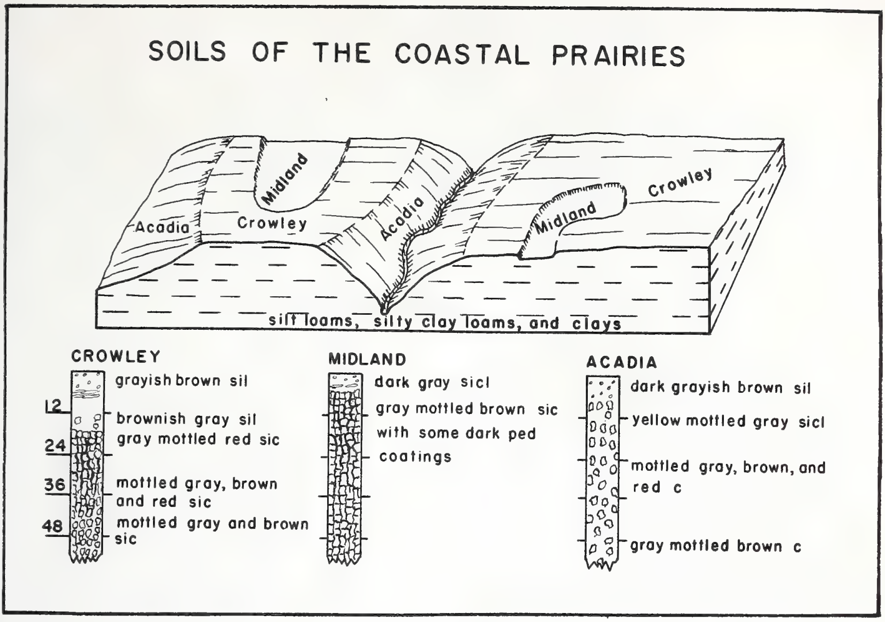

SOILS OF THE COASTAL PRAIRIES
Midland
Acadia
Crowley
Acadia
Crowley
Midland
silt loams, silty clay loams, and clays
CROWLEY
grayish brown sil
12
brownish gray sil
24
gray mottled red sic
36
mottled gray, brown and red sic
48
mottled gray and brown sic
MIDLAND
dark gray sicl
gray mottled brown sic with some dark ped coatings
ACADIA
dark grayish brown sil
yellow mottled gray sicl
mottled gray, brown, and red c
gray mottled brown c

Figure 5

(See Figure 3 for explanation of symbols.)

Soils of the Coastal Prairies
Approximately 1,662,720 acres

The important soil series of the Coastal Prairies are the Crowley soil on broad, level to undulating plains, and the Midland soil in shallow depressions and on flats. Associated with the soils of the Coastal Prairies is the Acadia soil that occupies the forested slopes along stream channels that cross the prairies. Crowley soil has a grayish-brown or gray silt loam surface that is about 16 inches thick over a gray silty clay subsoil, mottled with red and brown. The surface layers are massive or have a weak, granular structure, usually with a firm consistence when moist. The subsoil has a moderate to strong, compound blocky and prismatic structure, and a firm consistence when moist. Midland soil has a dark gray silty clay subsoil. The surface soil has a weak structure, but the subsoil has a moderate to strong, compound subangular blocky and prismatic structure, and a firm consistence when moist. The Acadia soil has a friable silt loam surface layer with a weak, granular structure and a mottled gray, brown, and red clay subsoil that is very firm when moist. The Acadia subsoil has a weak to moderate, subangular blocky structure.

Flatwoods Soils

Approximately 3,817,600 acres

Flat and nearly level areas of poorly drained and somewhat poorly drained forested soils are of common occurrence throughout the state. The largest areas of Flatwoods soils in Louisiana are located in the southwestern and southeastern parts.

Flatwoods Soils-Southwest

The dominant soils of this area are in the Caddo and Acadia series that occur on level and nearly level ridges, and the Beauregard and Acadia series that occur on sideslopes. A fifth series in this area is the Wrightsville soil that generally occupies level benches along stream channels. The surface soils are gray or grayish-brown, friable silt loams and very fine sandy loams with a weak structure. The organic matter content is generally low. The Beauregard soil has a mottled brown, yellow, and red, friable sandy clay loam subsoil with weak, subangular blocky structure. Caddo soil has a mottled yellow and gray, friable sandy clay loam subsoil with a weak, blocky structure. Acadia soil has a mottled gray, brown, and red, firm clay subsoil with a weak, blocky structure. Wrightsville soil has a gray, brown-mottled, very firm silty clay subsoil having a compound subangular blocky and prismatic structure.

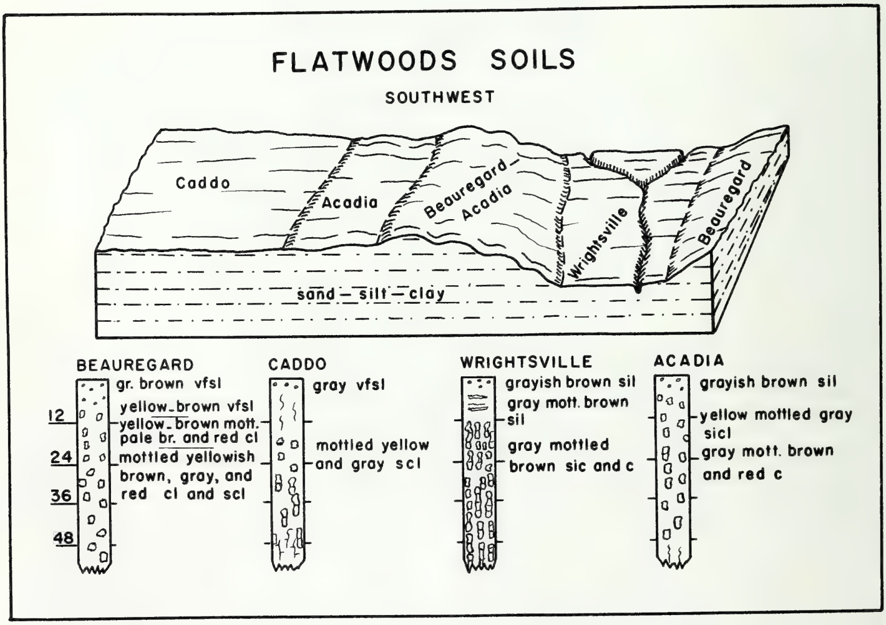


Figure 6

(See Figure 3 for explanation of symbols.)

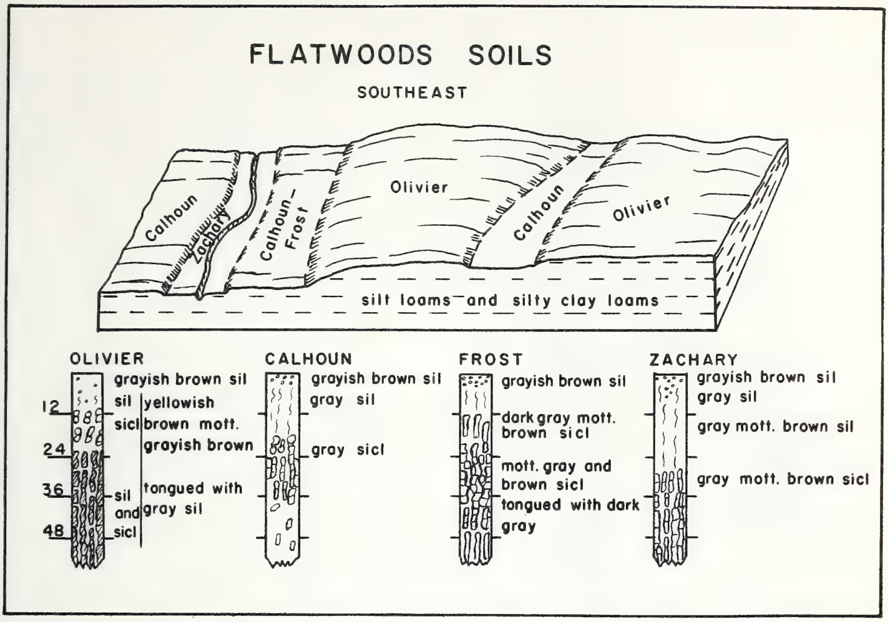


Figure 7

(See Figure 3 for explanation of symbols.)

Flatwoods Soils-Southeast

The typical landscape of the southeastern Flatwoods includes the somewhat poorly drained Olivier soil on level and nearly level ridges that lie a few inches above the poorly drained Calhoun and Frost soils, with Zachary soils in flats and depressions along drainageways. These soils have gray or grayish-brown, friable silt loam surface layers with weak structure. The subsoils are friable to firm silty clay loams having a compound subangular blocky and prismatic structure. Olivier soil has a brown, gray-mottled subsoil overlying a firm fragipan layer. Frost soil has a gray, brown-mottled subsoil that is tongued with gray and dark gray silt loam. Calhoun and Zachary soils have gray silty clay loam subsoils. The Calhoun subsoil lies at 16 inches below the surface. The Zachary subsoil is about 30 inches below the soil surface.

Loessial Hills and Mississippi Terraces

Approximately 2,430,000 acres

The soils representative of this area are the Memphis on level and sloping ridges and steeper sideslopes, the Loring on gently sloping ridges and sideslopes, the Olivier on nearly level and gently sloping ridges and on seepy footslopes, and the Calhoun on the level tops of ridges, on flats, and in depressions. All of these soils are silty throughout. They have friable silt loam surface layers, and friable to firm silty clay loam

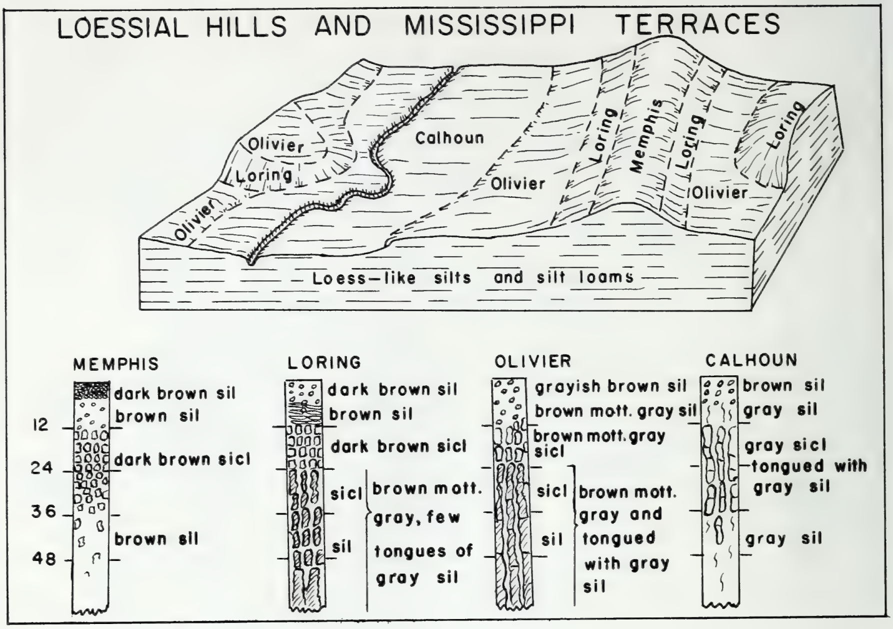


Figure 8

(See Figure 3 for explanation of symbols.)

subsoils. The surface soils have a weak to moderate, granular structure; the subsoils commonly have a moderate, subangular blocky structure. The Memphis soil is brown throughout and is well drained. Loring soil has brown surface and subsoil layers that are underlain by a fragipan. Olivier soil has a mottled brown and gray subsoil that is also underlain by a fragipan. Calhoun soil has a gray, firm to friable silt loam lower surface soil having weak structure. This is underlain by a firm to friable subsoil having a compound blocky and prismatic structure.

Coastal Plain Soils
Approximately 6,800,000 acres

This is the area of predominantly pine-forested slopes and hills that is located in the northern half of the state. The major soil series of the Coastal Plain area are separated into three groups on the basis of soil permeability: Coastal Plain Soils with Permeable Subsoils; Coastal Plain Soils with Moderately Permeable Subsoils; and Coastal Plain Soils with Slowly Permeable Subsoils.

Coastal Plain Soils With Permeable Subsoils

The major soil series representative of this group are Ruston, Bowie, Lucy, and Troup. The dominant morphological characteristics of these soils are thin, gray or grayish-brown surface soils that contain low amounts of organic matter, red, brown, and yellow subsoils that are aerated and highly oxidized, sandy soil textures, weak to moderate soil

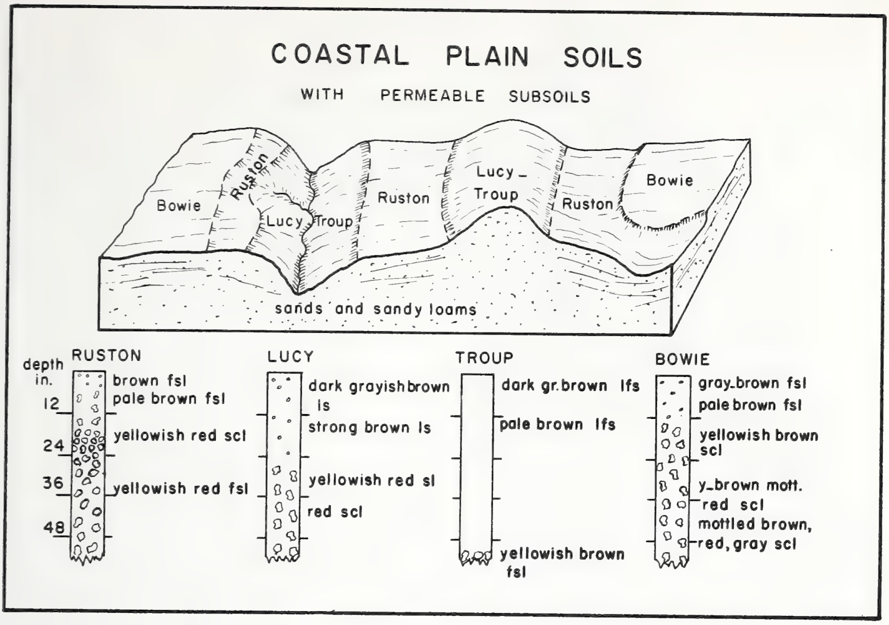


Figure 9

(See Figure 3 for explanation of symbols.)

structure, and friable to loose consistence when moist. The red Ruston subsoils and the yellowish-brown Bowie subsoils are friable sandy clay loams having a weak to moderate, subangular blocky structure. Lucy soil has a loose loamy sand surface layer that is underlain at 24 inches by a yellowish-red sandy clay loam subsoil that has a weak, subangular blocky structure. Troup soil has loamy fine sand and sand upper soil layers that have a single grain structure and a thickness of 50 inches over a yellowish-brown sandy loam subsoil.

Coastal Plain Soils With Moderately Permeable Subsoils

The major series of the moderately permeable Coastal Plain soils are Nacogdoches and Shubuta on gentle slopes and hilly areas, and Ora on level areas and gentle slopes. The Shubuta and Ora soils have grayish-brown, friable sandy loam surface soils with a weak, granular structure and contain low amounts of organic matter. Their subsoils are red or brown, friable sandy clay loam having a weak to moderate, subangular blocky structure. Shubuta and Ora soils have a fragipan or silty clay layer in the lower part of the subsoil that is firm and slowly permeable. The Nacogdoches soil has a reddish-brown, friable fine sandy loam surface layer with a moderate to strong, granular structure, and a red clay loam or sandy clay subsoil having a moderate, blocky structure and a firm to friable consistence. Thinly bedded lenses of ironstone commonly occur in the subsoil or throughout the soil profile.

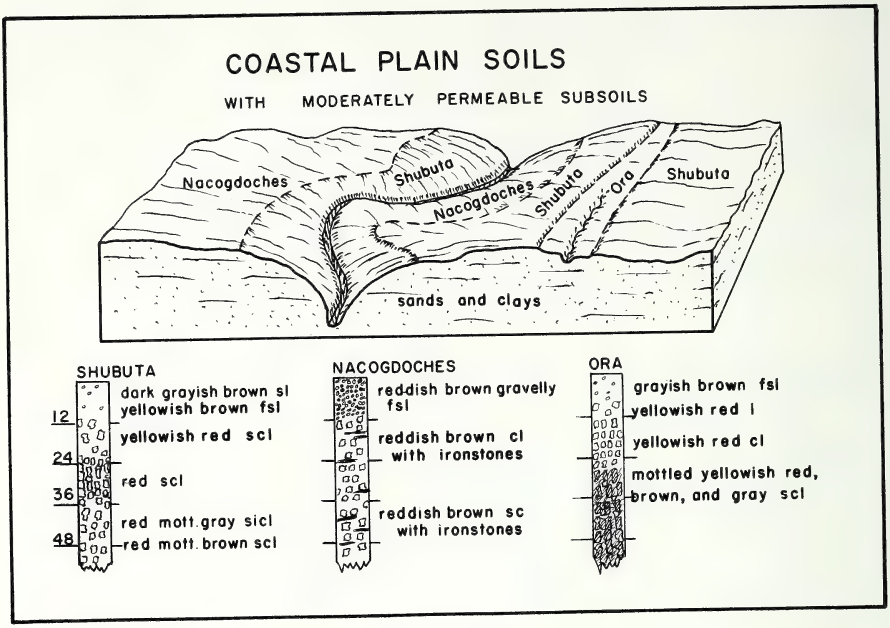


Figure 10

(See Figure 3 for explanation of symbols.)

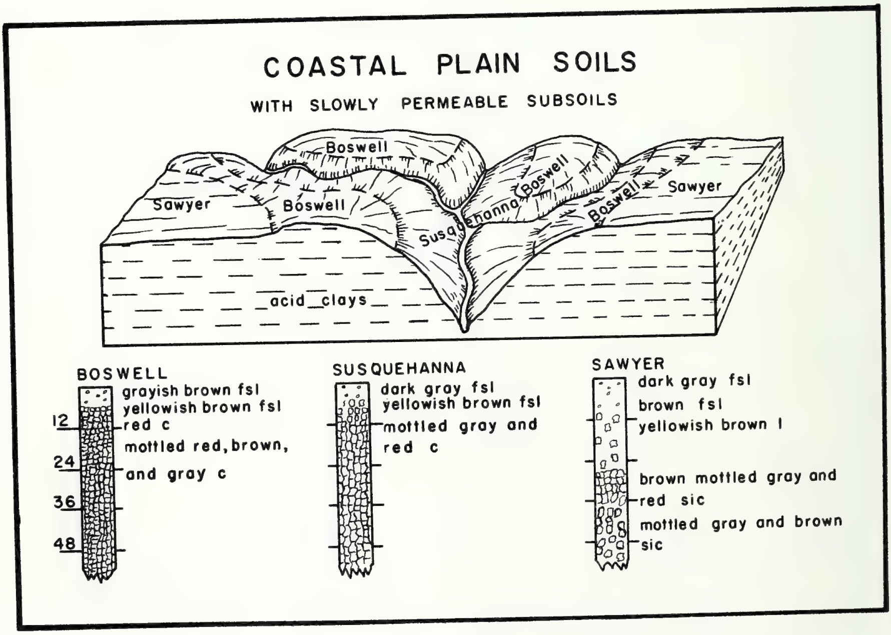


Figure 11

(See Figure 3 for explanation of symbols.)

Coastal Plain Soils With Slowly Permeable Subsoils

These soils include the Sawyer on nearly level and gently sloping ridges, the Boswell on gentle slopes, and the Susquehanna on gentle and steep slopes. They have grayish-brown, friable sandy loam surface soils over very firm, mottled gray, brown, and red clays that lie from 4 to 24 inches below the surface. Locally the surface soils are darkened to a depth of one to three inches by organic matter. Susquehanna has a surface layer that ranges from 4 to 10 inches in thickness over a moderate to strong, blocky clay subsoil. Boswell has a red, blocky clay subsoil 6 to 10 inches thick over mottled clay. Sawyer has a surface soil about 10 inches thick over a brown, friable loam or clay loam subsoil with a weak, blocky structure. It has a substratum of mottled clay having a moderate, blocky structure.

Interpretations of Morphological and Relief Characteristics

Much valuable information about soils may be obtained through a study of those physical properties than can be readily seen or easily measured. With this information, many interpretations can be made about the behavior of the soils under certain uses or systems of management. Predictions can be made about the suitability of the soils for selected uses and about the management requirements for continued economical crop production.

Soil moisture and plant relationships important for the profitable production of crops are reflected in the color, texture, structure, and consistence of the soils. Soils that are gray because of a high water table usually have a shallow rooting zone, and they are best suited to plants that are shallow-rooted. Most brown, red, and yellow soils have little or no restrictions to the development of deep root systems. Some coarse-textured soils such as sands and loamy sands are so limited in moisture content that they are poorly suited for many plants. However, adapted plant species may be selected that are suited to each of these different conditions of moisture supply.

Many important use and management problems are due to the influences of relief, or soil slope. Most rolling and hilly areas of excessive relief are susceptible to erosion unless stabilized by a good vegetative cover of grasses or trees. Soils on sharply convex ridges, knolls, and steep slopes where runoff is excessive have a local semi-arid climate. Only the more gently sloping areas are suitable for intensive use. Areas of flat or concave relief occupy basins and depressions that receive excess water by runoff from adjacent slopes, and they have a local super-humid climate. Both flood control and artificial drainage may be needed to provide favorable conditions for intensive cultivation of these wet soils. The use of adapted plant species and special management practices may be necessary for profitable crop yields on soils of the local semi-arid and super-humid sites.

Differences in the methods of effective irrigation of crops are largely governed by the slope, texture, structure, and consistence of the soils.

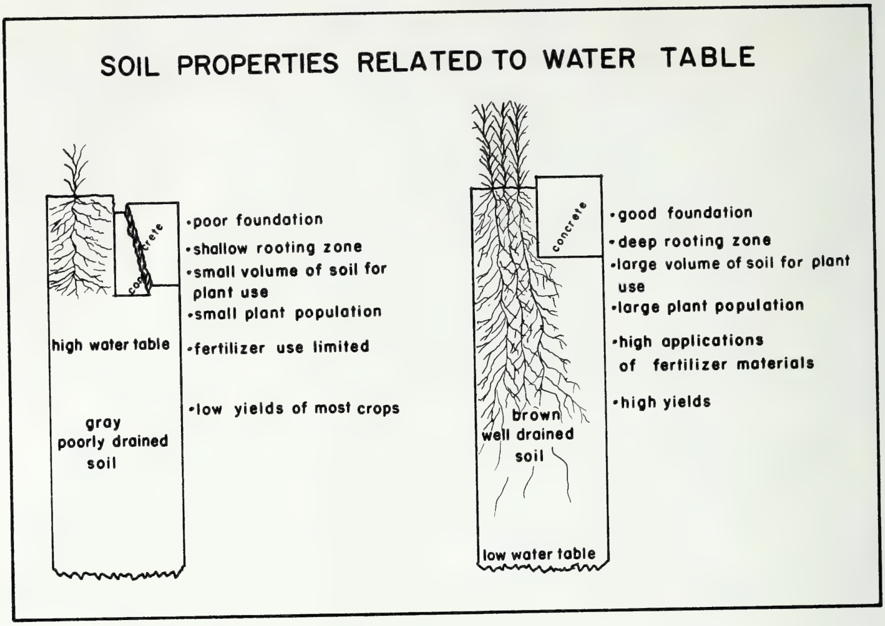


Figure 12

Many clay soils and soils with clayey subsoils are so slowly permeable that they may be flood-irrigated without excessive losses of irrigation water. Soils with silt loam and silty clay loam textures are better suited to furrow irrigation than the sandy-textured soils. Sprinkling is the most efficient method of irrigating crops on the permeable and excessively permeable sands and loamy sands.

Soil color and texture may be used to indicate the probable suitability of soils for engineering uses. The brown, red, and yellow soils, especially those having sandy loam, loam, or sandy clay loam textures, are generally well suited as foundation materials for building sites. These aerated, oxidized, well-drained soils are usually better suited for below-ground installations of iron structural materials than the gray-colored soils. Because of the high water table and wetness, most gray soils are not well suited for many engineering uses due to their lack of favorable stability under load, and to the possibility of damage to underground iron pipe by electrolytic corrosion. Some of the more important soil properties that are influenced by the height of the water table are illustrated in Figure 12.

Soil Classification and Soil Surveys

Soils have been classified and surveyed in most parts of the United States since about 1899 when the United States Bureau of Soils was established. This government agency was responsible for collecting soils information demanded by farmers, ranchers, U. S. Congressmen, and other groups that were interested in the conservation of the land and in the promotion of agriculture. The scope of this work was broadened under the U. S. Bureau of Chemistry and Soils, which was created in 1927, and it included the collection of chemical and mineralogical soils data that were needed in determining the fertility status of the soils. In 1952, the responsibility for conducting the National Cooperative Soil Survey was delegated to the U. S. D. A., Soil Conservation Service.

The system of soil classification used in the United States for the period of 1938 to 1965 was essentially the same as that presented in the 1938 Yearbook of Agriculture. The only important changes made in the classification system during this period were those published in Soil Science, Volume 67, February 1949.

A classification of soils is an orderly arrangement of many different facts, opinions, and ideas about soils that are assembled in such a manner that our knowledge of soils is more easily understood, retained, and applied. As more is learned about the soils, we find it necessary to revise our thinking and our classification systems. More and better information enables us to more accurately predict how soils will behave under different conditions of use and management. The new classification system is a complete revision of older systems of soil classification.

Responsible soil scientists, recognizing the numerous limitations of the 1938-1949 systems of soil classification, have dedicated much of their time toward its improvement. A wealth of valuable information about soils has accumulated as a result of the many years of soil investigations and soil surveys. This includes soil profile descriptions, soil testing, clay mineral analyses, and other chemical, physical, and mineralogical data. This soils information has been used in developing and improving the soil classification system. In 1965, a new, comprehensive system of soil classification was presented for field use throughout the United States. This comprehensive system is designed for the classification of all known soils of the world.

Subdivisions of the older systems of classification are commonly based on the genetic factors of soil formation. The comprehensive system is based on soil characteristics that are thought to be the result of genesis or the result of the influences of genesis.

The important soil series in Louisiana are listed in the following table as they occur in both systems of soil classification. For example, Acadia series is classified in the old system as belonging to the great soil group of Planosols. In the comprehensive system, Acadia is in the great group of Ochraqualfs of the order Alfisols.

CLASSIFICATION OF THE SOILS IN LOUISIANA UNDER THE OLD AND NEW SYSTEMS

Series	Classification System of 1938 (Revised 1949)	Comprehensive System Jan. 1965	
	Great Soil Group	Order	Great Group
Acadia	Planosols	Alfisols	Ochraqualfs
Baldwin	Low-Humic Gley	Alfisols	Ochraqualfs
Beaumont	Grumusols	Vertisols	Pelluderts
Beauregard	Red-Yellow Podzolic	Ultisols	Paleudults
Bernard	Reddish Prairies	Mollisols	Argiaquolls
Bibb	Low-Humic Gley	Entisols	Haplaquents
Boswell	Red-Yellow Podzolic	Alfisols	Paleudalfs
Bowie	Red-Yellow Podzolic	Utisols	Paleudults
Caddo	Low-Humic Gley	Alfisols	Glossaqualfs
Cahaba	Red-Yellow Podzolic	Utisols	Hapludults
Calhoun	Planosols	Alfisols	Glossaqualfs
Cascilla	Alluvial	Inceptisols	Dystrochrepts
Collins	Alluvial	Entisols	Udifluvents
Commerce	Alluvial	Inceptisols	Haplaquepts
Crowley	Planosols	Alfisols	Albaqualfs
Cypremort	Gray-Brown Podzolic	Alfisols	Ochraqualfs
Dundee	Planosols	Alfisols	Ochraqualfs
Frost	Low-Humic Gley	Alfisols	Glossaqualfs
Gallion	Gray-Brown Podzolic	Alfisols	Hapludalfs
Harris	Half-Bog	Inceptisols	Humaquepts
Hebert	Gray-Brown Podzolic-Planosols	Alfisols	Ochraqualfs
Iberia	Humic Gley	Mollisols	Haplaquolls
Jeanerette	Humic Gley	Mollisols	Argiaquolls
Kirvin	Reddish-Brown Lateritic	Ultisols	Hapludults
Lexington	Gray-Brown Polzolic	Alfisols	Hapudalfs
Loring	Planosols	Alfisols	Fragiudalfs
Lucy	Red-Yellow Podzolic	Ultisols	Paleudults
Marsh Peats	Bog	Histosols	———
Marsh Mucks	Bog	Histosols	———
Memphis	Gray-Brown Podzolic	Alfisols	Hapludalfs
Mhoon	Low-Humic Gley	Inceptisols	Haplaquepts
Midland	Planosols	Alfisols	Ochraqualfs
Moreland	Alluvial-Grumusols	Mollisols	Hapludolls
Nacogdoches	Reddish-Brown Lateritic	Ultisols	Paleudults
Norwood	Alluvial	Entisols	Udifluvents
Olivier	Planosols	Alfisols	Fragiudalfs
Ora	Planosols	Ultisols	Fragiudults
Perry	Low-Humic Gley-Grumusols	Inceptisols	Haplaquepts
Portland	Low-Humic Gley	Inceptisols	Eutrochrepts
Prentiss	Planosols	Ultisols	Fragiudults
Providence	Planosols	Alfisols	Fragiudalfs
Pulaski	Alluvial	Entisols	Ustifluvents
Ruston	Red-Yellow Podzolic	Ultisols	Paleudults
Sawyer	Red-Yellow Podzolic	Ultisols	Paleudults
Sharkey	Grumusols	Inceptisols	Haplaquepts
Shubuta	Red-Yellow Podzolic	Ultisols	Paleudults
Stough	Planosols	Ultisols	Fragiudults
Susquehanna	Red-Yellow Podzolic	Alfisols	Paleudalfs
Troup	Red-Yellow Podzolic-Regosols	Ultisols	Paleudults
Tunica	Grumusols	Inceptisols	Haplaquepts
Waverly	Low-Humic Gley	Inceptisols	Haplaquepts
Wrightsville	Planosols	Alfisols	Glossaqualfs
Yahola	Alluvial	Entisols	Ustifluvents
Zachary	Low-Humic Gley	Alfisols	Albaqualfs

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ANALYTICAL METHODS AND PROCEDURES USED IN THE SOIL TESTING LABORATORY

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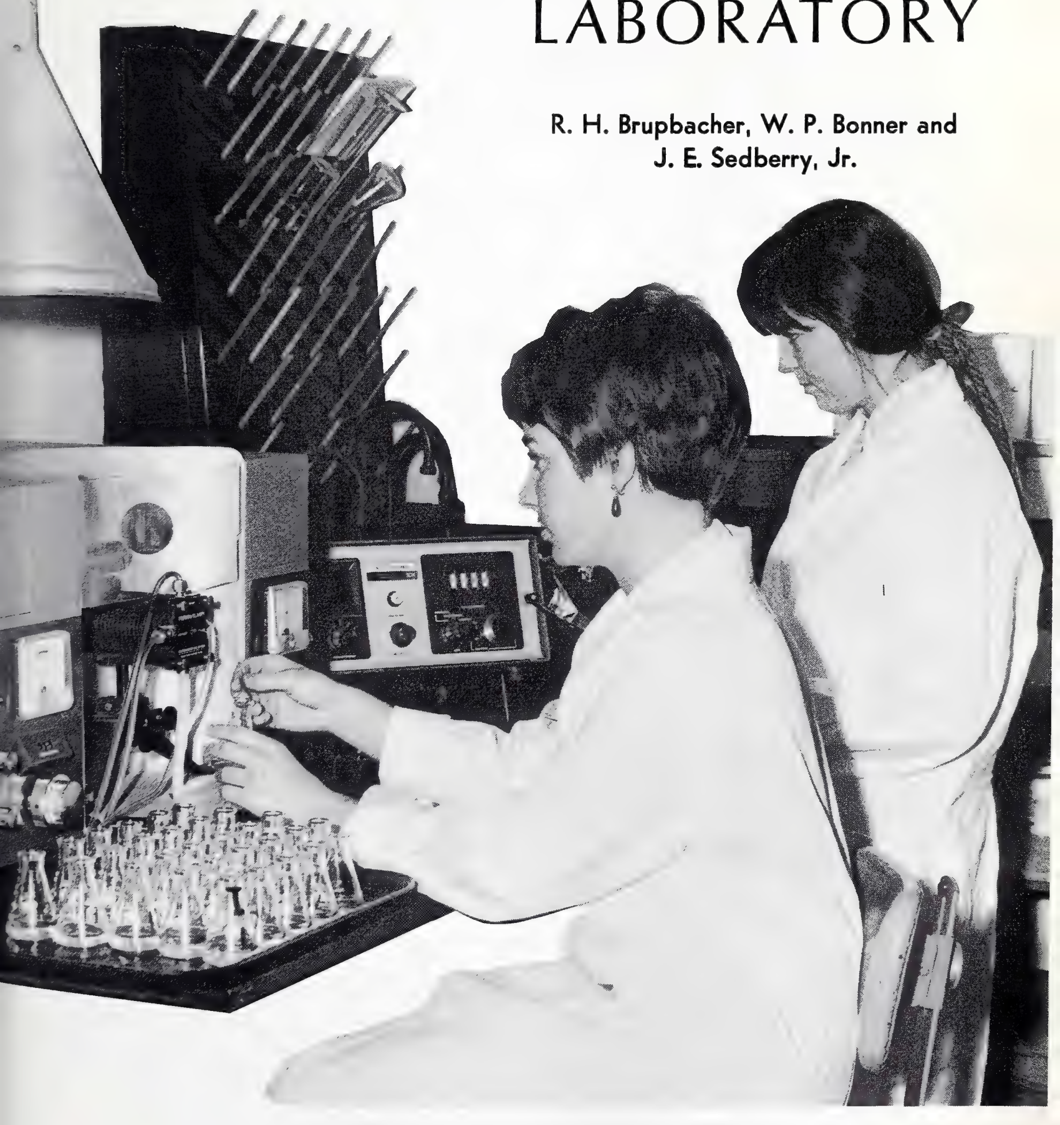

LOUISIANA STATE UNIVERSITY
AND AGRICULTURAL AND MECHANICAL COLLEGE
DEPARTMENT OF AGRONOMY
AGRICULTURAL EXPERIMENT STATION
DOYLE CHAMBERS, DIRECTOR

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COVER PICTURE—Atomic Absorption Spectrophotometer is used in the Soil Testing Laboratory at Louisiana State University to determine magnesium content of a soil sample.

Acknowledgment

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Analytical Methods and Procedures Used in The Soil Testing Laboratory

Department of Agronomy
Louisiana Agricultural Experiment Station
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Introduction

The soil testing laboratory is operated by the Department of Agronomy as a service to farmers and for the purpose of determining the fertility levels and lime status of soils used for crop production. The fertility level and lime status of soils, in conjunction with a knowledge of certain production practices, serve as a guide in making recommendations for plant nutrient additions for correcting deficiencies or maintaining adequate plant nutrient levels in soils for sustained high-level production.

The laboratory is also concerned with making chemical analyses of soils on which experiments are conducted at the Branch Experiment Stations in Louisiana and on out-field research locations where experiments are conducted in cooperation with crop and livestock producers. Soil samples are also processed and analyzed from uniform regional experiments and cooperative soil investigations in the states in the Southern Region of the United States.[2]

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During 1967, approximately 15,000 soil samples were processed and analyzed. Over 90,000 individual chemical analyses were made on these samples. This represented an increase of 30 per cent over the number of samples analyzed during the preceding year. Because of the increased emphasis on high yields and improved crop quality, an increase in the number of soil samples submitted for analysis is expected for each year in the future. To facilitate the chemical analyses of a large number of soil samples and to improve the analytical techniques employed in the laboratory, new instrumentation has been introduced. At the same time, a higher degree of accuracy in the chemical determinations has been attained.

The analytical methods and procedures formerly employed in the soil testing laboratory at Louisiana State University were published in Bulletin Number 102, Southern Cooperative Series, June, 1965 (*11*).[3] Because of improvements in instrumentation and modifications in analytical techniques, the methods and procedures in use as recently as one year ago have been revised. The primary purpose of this publication is to briefly describe the analytical methods, procedures, and techniques currently in use in the soil testing laboratory.

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[1] Assistant Professor, Associate, and Professor, respectively.

[2] In cooperation with S-52 Regional Technical Committee.

[3] Italic numbers in parentheses refer to Literature Cited, page 15.

General Laboratory Determinations

Chemical analyses of soil samples include determinations of soil reaction (pH) and lime requirement, extractable calcium, magnesium, potassium, and phosphorus. The contents of extractable sodium and total soluble salts are determined on some soil samples from research and specific problem areas. Textural class is determined by feel.

Soil reaction (pH) is determined by using a pH-meter and a slurry of soil and distilled water at a soil-to-water ratio of approximately 1:1. An estimation of the amount of lime required to adjust the soil reaction to a desired level is made by increment potentiometric titration of a soil with a 0.04 normal solution of calcium hydroxide and distilled water. The hydrogen ion activity of a slurry composed of soil, distilled water, and calcium hydroxide is measured on a pH-meter.

Two different extracting solutions are employed to determine the content of the soil cations calcium, magnesium, potassium, and sodium and the content of soil phosphorus.

The soil cations calcium, magnesium, potassium, and sodium are determined by a method first proposed by Reed and Sturgis (*13*) and later modified and adapted by Stelly, Brupbacher, and Ricaud (*16*) for the analysis of a large number of soil samples. A sample of soil is extracted with a 0.10 normal hydrochloric acid solution using a soil-to-extraction solution ratio of 1:20. The contents of calcium, potassium, and sodium in the soil are determined on the extract, without further dilution, on a flame spectrophotometer. The concentration of magnesium in the extract is determined, without further dilution, on the atomic absorption spectrophotometer.

Phosphorus is determined by a method proposed by Bray and Kurtz (*3*) and modified, correlated, and calibrated with crop yields by Byrnside and Sturgis (*4*). Dilute acid-extractable and adsorbed phosphorus are determined simultaneously by extracting a sample of soil with a solution of 0.10 normal hydrochloric acid containing 0.03 normal ammonium fluoride. A soil-to-solution ratio of 1:20 and an extracting period of 15 minutes are used to determine extractable phosphorus. The concentration of phosphorus in the soil is determined on an aliquot of the soil extract after a color is developed upon adding a solution containing ammonium molybdate, sulphuric acid, and boric acid and an acidified solution containing stannous chloride. The intensity of the color developed is measured on a spectrophotometer using standard reference solutions containing known amounts of phosphorus for comparison.

Soil Sample Preparation

Soil samples received in the laboratory are opened daily, assigned a laboratory number, and placed in 12" x 12" stainless steel pans for air drying. Oscillating fans circulating air over the soil samples for a period of 24 hours facilitate drying. The samples are ground mechanically in a Bico Type U A pulverizer so that the particles will pass through a U. S.

Standard Sieve No. 10 with 2-millimeter openings. Samples containing excessive amounts of crop residues and undecomposed organic material are passed through a sieve prior to grinding to remove extraneous material.

The Determination of Soil Reaction (pH)

According to Truog *(17)*, soil reaction, or pH, is the most important single chemical characteristic of a soil that determines its suitability for plant growth. The test for soil reaction is by far the simplest and most commonly made test by state soil testing laboratories *(11)*. It is widely used as a means for estimating the limestone needs of soils.

The pH of a solution is defined as the negative logarithm of the hydrogen-ion concentration. Since hydrogen-ion activity, rather than hydrogen-ion concentration, is actually measured by potentiometric methods, it should be more useful and correct to define pH as the negative logarithm of the hydrogen-ion activity *(12)*. This conventional manner of expressing hydrogen-ion concentration has been widely adopted for convenience, but there is another distinct advantage of using the pH scale for estimating lime requirement of soils from soil reaction. In the pH range from 4.5 to 6.5, there is a linear relationship between the pH value of the soil and its degree of base saturation *(14)*. Thus, within this range, the pH value of any soil should increase linearly with increasing amounts of applied limestone.

Chemical Reagents: *1. Buffer Solution, pH 4.0.*—Exactly 20.44 grams of potassium acid phthalate, dried at 105 degrees centigrade, are dissolved in 1,000 milliliters of distilled water.

2. Buffer Solution, pH 7.0.—Dilute 40 milliliters of Beckman (3581) buffer solution, pH 7.0 concentrate, to 1,000 milliliters with distilled water.

Procedure: Approximately 35 grams of air-dried soil are placed into a 4¼-ounce paper cup and 35 millilters of distilled water are added with a filamatic vial filler. The force of delivery is sufficient to thoroughly mix the soil and water.

After 24 hours the suspension is agitated with an electric stirrer and the soil reaction (pH) is determined by inserting the electrodes into the suspension. A Leeds and Northrup No. 7401 pH-meter has proved to be very satisfactory for soil analysis. The pH-meter is standardized by using buffer solutions adjusted to pH 4.0 and pH 7.0.

Comments: There has been little agreement among different investigators as to the use of the proper soil-water ratio in preparation of the soil suspension for pH measurement. Since the reaction of soils generally increases with increasing dilution of the soil with water, the pH values obtained at such high dilutions as 5 or 10 parts of water to 1 part of soil may be questionable. After a thorough review of the literature, Reed and Cummings *(14)* concluded that "the pH value is erratic and unreliable when determinations are made on soils with moisture contents at or below the moisture equivalent." The use of the 1:1 soil-to-water ratio has been adopted by many state soil testing laboratories in the Southern Region of the United States (*11*) and appears to offer a good compromise for routine determination of soil reaction.

The Determination of the Lime Requirement of Soils

Many procedures have been developed for measuring the lime requirement of soils, which is defined as the amount of lime needed to bring the pH value from its present value to any desired pH value.

According to Peech (*12*), the better lime requirement procedures involving the use of hydroxides are based on serial potentiometric titration of the soil with calcium hydroxide, using the glass electrode for measurement of the reaction of the soil. The method used by the Louisiana State University Soil Testing Laboratory to measure the lime requirement of a soil is essentially the method described by Dunn (*6*), and is based on the establishment of a titration curve for a particular soil.

Chemical Reagents: *1. Calcium Hydroxide Solution.*—A solution is prepared containing approximately 1.5 grams of reagent-grade calcium hydroxide per liter of distilled water. The solution is thoroughly mixed and allowed to stand until the excess calcium hydroxide has precipitated. The normality and pH of the saturated solution of calcium hydroxide is determined and recorded. Generally, the normality of the solution of $Ca(OH)_2$ is approximately 0.04 normal. The pH of this solution is approximately 12.0.

2. Buffer Solution, pH 4.0.

3. Buffer Solution, pH 7.0.

Procedure: The method used for estimating the lime requirement of a soil involves increment potentiometric titration of a soil sample with a solution of calcium hydroxide of known normality. Ten-gram samples of soil are placed into 4¼-ounce paper cups. Twenty-five milliliters of distilled water and 2.5-milliliter increments of a 0.04 normal calcium hydroxide solution are added to each sample. The soil sample is thoroughly stirred, allowed to stand approximately 24 hours, and then stirred again. After 48 hours the samples are stirred, and the pH is determined with a glass electrode and a calomel reference electrode.

The calcium hydroxide solution is added with an automatic vial filler which is calibrated to deliver, with each stroke of the filler, a volume of solution that is equivalent to 1,000 pounds of pure calcium carbonate per acre. The number of increments of calcium hydroxide used in the titration will depend upon the initial soil reaction, the soil reaction desired, the crop that is to be produced, and the soil texture.

Increments of calcium hydroxide added to samples of soil, calcium carbonate equivalents, and agricultural limestone conversions used to interpret the results obtained in estimating the lime requirement of a soil are presented in Table 1.

TABLE 1.—Increments of calcium hydroxide added to samples of soil, calcium carbonate equivalents, and agricultural limestone conversions used to interpret the results obtained in estimating the lime requirements of a soil

Increments of 0.04 N $Ca(OH)_2$	$CaCO_3$ Equivalent[1]	Agricultural Limestone Conversions[2]
Ml. per 10 g. soil	Pounds per acre	Pounds per acre
2.5	1,000	2,000
5.0	2,000	4,000
7.5	3,000	6,000
10.0	4,000	8,000

[1] Values shown are based on reagent-grade calcium hydroxide and calcium carbonate.

[2] Values are calculated from calcium carbonate equivalents, assuming that agricultural liming materials are 50 per cent as effective as pure calcium carbonate.

Comments: The calcium hydroxide titration method is not considered to be a rapid method for assessing lime needs of soils, since approximately three days are required for the reaction of calcium hydroxide with acid soil to come to equilibrium. Actually, about 97 per cent of the reaction is complete in this time and the true equilibrium is attained only after many days (*5*).

Calcium chloride may be used to hasten the establishment of equilibrium of the calcium hydroxide and the soil; however, the pH value at any point on the titration curve is much lower in the presence of the calcium chloride, although the equivalence point may not be changed appreciably by its addition (*12*).

The Determination of Calcium, Magnesium, Potassium, and Sodium in Soils

Calcium, magnesium, potassium, and sodium exist in soils as cations that are adsorbed on the collodial complex and are present in the soil solution. The determination of the cations has been studied rather extensively during the past 50 years. The classical gravimetric, colorimetric, and volumetric methods used in former years have largely been replaced by equally accurate, but more rapid, methods. With the introduction of new instrumentation, spectrophotometric and flame photometric methods have been widely used for the determination of the concentration of cations in soils (*11*).

Extracting soils with a dilute acid, such as approximately 0.10 normal hydrochloric acid, for the determination of the soil cation affords a means of obtaining a reliable measurement of these elements which may serve as a guide in evaluating the fertility level of soils.

Extracting Solution for Calcium, Magnesium, Potassium, and Sodium

The extracting solution used for calcium, magnesium, potassium, and sodium is 0.10 normal hydrochloric acid. The extracting solution is prepared in the following manner.

A 2.5 normal stock solution of hydrochloric acid is prepared by diluting 207.2 milliliters of concentrated hydrochloric acid, assaying 37 per cent pure acid with a specific gravity of 1.189, to 1,000 milliliters with distilled water. The solution is standardized by titrating the acid solution into a known amount of sodium carbonate, using phenolphthalein and bromcresol green as indicators. The extracting solution is prepared by diluting 1,600 milliliters of the 2.5 normal hydrochloric acid solution to exactly 40 liters. This is a 0.10 normal hydrochloric acid solution.

Procedure for Extracting Calcium, Magnesium, Potassium, and Sodium

A 2.5-gram sample of air-dry soil is placed into a 125-milliliter Erlenmeyer flask. Fifty milliliters of the 0.10 normal hydrochloric acid extracting solution are added to the soil sample and this mixture is agitated for 15 minutes on an automatic shaking machine. The soil suspension is filtered through Whatman No. 12 folded filter paper into a 50-milliliter Erlenmeyer flask. Calcium, magnesium, potassium, and sodium are determined on the extract without further dilution.

The Determination of Calcium in Soils

Chemical Reagents: A standard calcium solution is prepared by dissolving 2.4972 grams of oven-dried reagent-grade calcium carbonate in a solution containing approximately 500 milliliters of distilled water and 8 milliliters of concentrated hydrochloric acid. This solution is diluted to 1,000 milliliters with 0.10 normal hydrochloric acid and contains 1,000 parts per million of calcium. The 1,000-parts-per-million calcium solution serves as a stock solution from which other standard calcium reference solutions are prepared.

Five standard reference solutions containing 0, 50, 100, 150, and 200 parts per million of calcium are prepared by measuring 0, 25, 50, 75, and 100 milliliters of the solution containing 1,000 parts per million of calcium and transferring these to 500-milliliter volumetric flasks. The calcium standards are diluted to a volume of 500 milliliters with 0.10 normal hydrochloric acid.

Procedure: The concentration of calcium in the soil solution extract is determined by means of a Beckman Model DU Flame Spectrophotometer. The instrument settings are listed in Table 2.

The per cent transmittance of each of the calcium standard reference solutions and the soil solution extract is measured according to the operating procedure described in Section II of the Instruction Manual for the Beckman Model DU Flame Spectrophotometer (7). The amount of calcium in the soil solution extract is determined by referring to a calibration curve obtained by plotting the per cent transmittance readings against the calcium concentration of the five reference solutions.

TABLE 2.—Operating conditions for the Beckman Model DU Flame Spectrophotometer and the Beckman Model B Flame Spectrophotometer employed to determine the concentrations of calcium, sodium, and potassium in soil extracts

Operating Conditions	Beckman Model DU		Beckman Model B
	Calcium	Sodium	Potassium
Oxygen, psi.	20.0	20.0	20.0
Acetylene, psi.	4.0	4.0	3.5
Wave length, millimicrons	422.7	590.0	765.0
Sensitivity	2.0	2.0	4.0
Zero suppression	1.0	1.0	——
Photo tube	Blue	Blue	Red
Slit width, mm.	0.03	0.01	0.35
Load resistor	2.0	2.0	——

The Determination of Magnesium in Soils

Chemical Reagents: A standard magnesium solution is prepared by dissolving one gram of reagent-grade magnesium metal in dilute hydrochloric acid solution containing 400 milliliters of distilled water and 20 milliliters of concentrated hydrochloric acid. This solution, diluted to 1,000 milliliters with distilled water, contains 1,000 parts per million of magnesium. A solution containing 100 parts per million of magnesium is prepared by diluting exactly 100 milliliters of the 1,000-parts-per-million magnesium solution to 1,000 milliliters with distilled water. The solution containing 100 parts per million of magnesium serves as a stock solution from which other standard magnesium reference solutions are prepared.

Five standard reference solutions containing 0, 5, 10, 15, and 20 parts per million are prepared by measuring 0, 25, 50, 75, and 100 milliliters of a solution containing 100 parts per million of magnesium and transferring these to 500-milliliter volumetric flasks. The magnesium standards are diluted to a volume of 500 milliliters with a 0.10 normal hydrochloric acid solution.

Procedure: The concentration of magnesium in the soil solution extract is determined with the use of a Perkin-Elmer Model 303 Atomic Absorption Spectrophotometer. The instrument settings are shown in Table 3.

TABLE 3.—Operating conditions and instrument settings for the Perkin-Elmer Model 303 Atomic Absorption Spectrophotometer used to determine the concentration of magnesium in soil extracts

Operating Conditions	Instrument Settings
Wave length, 2852 Angstroms	Range, ultraviolet
Slit	Slit, 5
Source, Hollow cathode	Source, 6 milliamps.
Fuel, Acetylene	Flow, 5 psi.
(Reducing flame)	
Oxidizer, Air	Flow, 4 psi.

The per cent absorption of each of the magnesium standard reference solutions and the soil solution extract is measured according to the operating procedures described in Section II, B, page 12 of the Instruction Manual for the operation of the Perkin-Elmer Model 303 Atomic Absorption Spectrophotometer (*8*). The per cent absorption of each of the magnesium standard solutions and the soil solution extract is converted to absorbance by using Table III on page 7 of the instruction manual. The amount of magnesium present in the soil solution extract is determined by referring to a calibration curve obtained by plotting the absorbance readings against the magnesium concentration of the five reference solutions.

The Determination of Potassium in Soils

Chemical Reagents: A standard potassium solution is prepared by dissolving exactly 0.9530 gram of oven-dried reagent-grade potassium chloride in 100 milliliters of distilled water. Dilute to 1,000 milliliters with a 0.10 normal hydrochloric acid solution. This solution contains 500 parts per million of potassium and serves as a stock solution from which other standard potassium reference solutions are prepared.

Five standard reference solutions containing 0, 5, 10, 20, and 25 parts per million are prepared by measuring 0, 5, 10, 20, and 25 milliliters of the solution containing 500 parts per million of potassium and transferring them to 500-milliliter volumetric flasks. The potassium standards are diluted to a volume of 500 milliliters with a 0.10 normal hydrochloric acid solution.

Procedure: The concentration of potassium in the soil solution extract is determined by means of a Beckman Model B Flame Spectrophotometer. The instrument settings are listed in Table 2. The per cent transmittance of each of the potassium standard reference solutions and the soil solution extract is measured according to the operating procedure described in Section D of the Instruction Manual for the Beckman Model B Flame Spectrophotometer (7). The amount of potassium in the soil solution extract is determined by referring to a calibration curve obtained by plotting the per cent transmittance readings against the potassium concentration of the five reference solutions.

The Determination of Sodium in Soils

Chemical Reagents: A standard sodium solution is prepared by dissolving 1.2710 grams of oven-dried reagent-grade sodium chloride in 100 milliliters of distilled water. Dilute to 1,000 milliliters with a 0.10 normal hydrochloric acid solution. This solution contains 500 parts per million of sodium and serves as a stock solution from which other standard sodium reference solutions are prepared.

Five standard reference solutions containing 0, 5, 10, 20, and 25 parts per million are prepared by measuring 0, 5, 10, 20, and 25 milliliters of the solution containing 500 parts per million of sodium and transferring them to 500-milliliter volumetric flasks. The sodium standards are diluted to a volume of 500 milliliters with a 0.10 normal hydrochloric acid solution.

Procedure: The concentration of sodium in the soil solution extract is determined by means of a Beckman Model DU Flame Spectrophotometer. The instrument settings are listed in Table 2. The per cent transmittance of each of the sodium standard solutions and the soil solution extract is measured according to the operating procedure described in Section II of the Instruction Manual for the Beckman DU Flame Spectrophotometer *(7)*. The amount of sodium present in the soil solution extract is determined by referring to a calibration curve obtained by plotting the per cent transmittance readings against the sodium concentration of the five reference solutions.

Comments

The use of 0.10 normal hydrochloric acid for determining extractable calcium, magnesium, potassium, and sodium affords a rapid and reliable index of the status of these elements in the soils of Louisiana. Unpublished data on file in the Department of Agronomy indicate that the dilute acid extractant currently in use in the Louisiana State University Soil Testing Laboratory compares favorably with ammonium acetate used to determine exchangeable cations.

The Determination of Phosphorus in Soils

The dilute acid-soluble and ammonium flouride-extractable phosphorus method has been used extensively as an index of the availability of phosphorus in soils. The combination of hydrochloric acid and ammonium fluoride is designed to extract the easily acid-soluble fraction of phosphorus, principally calcium phosphates, and a part of the aluminum and iron phosphates. The ammonium fluoride dissolves only aluminum and iron phosphates by its complex ion formation with these metal ions in acid solution *(10)*.

Aluminum and iron phosphates are relatively more abundant in soils having pH values below 6.0 than they are in soils with higher pH values *(3)*. Iron and aluminum forms of phosphorus are particularly important in evaluating extractable phosphorus in soils in Louisiana that are acid in reaction. These forms of native soil phosphorus are of much less importance in estimating the soil phosphorus that is available to crops grown on recent alluvial soils having a soil reaction approaching neutrality *(4)*.

Chemical Reagents: *1. Ammonium Molybdate-Sulphuric Acid-Boric Acid Solution*—Dissolve 5 grams of ammonium molybdate, $(NH_4)_6Mo_7O_{24} \bullet 4H_2O$, in approximately 100 milliliters of distilled water in a 250-milliliter Erlenmeyer flask. The distilled water may be heated to approximately 60 degrees centigrade to facilitate dissolution of the ammonium molybdate. Add 55 milliliters of reagent-grade concentrated sulphuric acid to 800 milliliters of distilled water in a 1,000-milliliter volumetric flask. Cool both solutions. Slowly add the ammonium molybdate solution to the sulphuric acid solution and gently shake the solutions. Dissolve 40 grams of reagent-grade boric acid, H_3BO_3, in the solution containing ammonium molybdate and sulphuric acid. This solution, diluted to a final volume of 1,000 milliliters, contains 0.005 gram of ammonium molybdate and 0.04 gram of boric acid per milliliter of solution and is approximately 2 normal with respect to the sulphuric acid.

2. *Standard Phosphorus Solution*—Dissolve 0.2195 gram of recrystallized potassium dihydrogen phosphate, KH_2PO_4, (dried for one hour at 105 degrees centigrade) in distilled water and dilute to 1,000 milliliters (*5*). This solution of potassium dihydrogen phosphate contains 50 parts per million of phosphorus. A solution containing 5 parts per million of phosphorus is prepared by diluting exactly 100 milliliters of the 50-parts-per-million phosphorus solution to 1,000 milliliters with distilled water. The solution containing 5 parts per million of phosphorus serves as a stock solution from which other standard phosphorus solutions are prepared.

3. *Stannous Chloride Solution*—Dissolve 25 grams of stannous chloride, $SnCl_2 \bullet 2H_20$, in 1,000 milliliters of dilute hydrochloric acid, 10 per cent by volume. The acidified solution of stannous chloride should be filtered if a precipitate develops. A thin layer of mineral oil should be added to the stannous chloride to prevent deterioration.

4. *Extracting Solution for Phosphorus*—The extracting solution used for the phosphorus is composed of a mixture of 0.10 normal hydrochloric acid and 0.03 normal ammonium fluoride. The extracting solution is prepared as shown in steps *A, B,* and *C* below.

(*A*) A 2.5 normal solution of hydrochloric acid is prepared by diluting 207.2 milliliters of concentrated hydrochloric acid, assaying 37 per cent pure acid with a specific gravity of 1.189, to 1,000 milliliters with distilled water. The solution is standardized by titrating the acid solution into a known amount of sodium carbonate using phenolphthalein and bromcresol green as indicators.

(*B*) A 1.5 normal solution of ammonium fluoride is prepared by dissolving 55.56 grams of reagent-grade ammonium fluoride in distilled water and diluting the solution to a final volume of 1,000 milliliters. The ammonium fluoride solution is stored in an opaque polyethylene bottle.

(*C*) The extracting solution is prepared by mixing 1,000 milliliters of the 2.5 normal hydrochloric acid solution with 500 milliliters of the 1.5 normal ammonium fluoride solution and diluting these two solutions to exactly 25 liters with distilled water. The extracting solution is 0.10 normal in hydrochloric acid and 0.03 normal in ammonium fluoride.

Procedure: A 2.5-gram sample of air-dried soil is placed in a 125-milliliter Erlenmeyer flask. Fifty milliliters of the phosphorus extracting solution are added to the soil sample. The soil sample and extracting solution are agitated for 15 minutes on an automatic shaking machine. The soil suspension is filtered through Whatman No. 12 folded paper, and the extract is collected in a 50-milliliter Erlenmeyer flask. A 3-milliliter aliquot of the solution extract is transferred to a 125-milliliter Erlenmeyer flask. Thirty-seven milliliters of distilled water and 10 milliliters of the ammonium molybdate-sulphuric acid-boric acid solution are added to the 3-milliliter aliquot.

Seven phosphorus standard reference solutions containing 0.0, 0.1, 0.2, 0.4, 0.6, 0.8, and 1.0 part per million are prepared by measuring 0, 1, 2, 4, 6, 8, and 10 milliliters of a solution containing 5 parts per million of phosphorus and transferring these to 50-milliliter volumetric flasks. Twenty milliliters of distilled water, 3 milliliters of the phosphorus extracting solution, and 10 milliliters of the ammonium molybdate-sulphuric acid-boric acid solution are added to each of the seven phosphorus standard solutions. The standards are diluted to a volume of 50 milliliters with distilled water.

Three drops of the stannous chloride solution are added to the phosphorus standards and to the aliquot of the soil solution extract. Ten minutes are allowed after the addition of the stannous chloride for complete chemical reaction which results in maximum color development. The optical density of the phosphorus solution is recorded by means of a Bausch and Lomb Spectronic 20 Spectrophotometer. A red filter and a wave length of 650 millimicrons are used to measure the phosphorus concentration in the phosphorus standard reference solutions and in the soil solution extract. The amount of phosphorus present in the soil solution extract is determined by reference to a calibration curve obtained by plotting the optical density readings against the phosphorus concentration in the seven standard reference solutions.

Comments: Boric acid eliminates possible interference of fluoride in the ammonium molybdate color development. However, the necessity for using boric acid for the analysis of most soils has not been established. Interference from fluorides may be encountered on some acid sandy soils (*10*).

The Determination of Water Soluble Salts in Soils

The term "soluble salts" as applied to soils refers to the inorganic soil constituents that are appreciably soluble in water (*2*). The determination of soluble salts consists essentially of two steps: (1) the preparation of a soil-water extract, and (2) the measurement of the salt concentration of the extract.

Soluble salts produce harmful effects to plants by increasing the salt content of the soil, thus affecting the osmotic pressure of the soil solution, and by increasing the degree of saturation of the exchange complex with exchangeable sodium (*2, 15*). With a given quantity of dissolved salt present in the soil, the salt concentration of the soil solution varies inversely with the water content of the soil. The water content of soils in which plants are growing generally fluctuates between a lower limit which may approach the wilting point and an upper limit which is near the field capacity. The upper and lower limits of field-water contents vary directly with the degree of fineness of the soil. For example, at both the upper and lower limits, a clay soil may contain five times as much water as a sandy soil. If the clay and sandy soils have equal contents of soluble salts expressed on a dry-soil basis, it is evident that, because of the inverse relation between salt concentration and water content, the salt concentration of the soil solution at both limits will be approximately five times as great for the sandy soil as for the clay soil.

The amounts of total salts extracted from soils are influenced to some extent by the water content at which the extract is made. Usually, the total quantity of dissolved salts increases with increasing water content. This phenomenon is probably due to exchange reactions in which dissolved divalent cations replace adsorbed univalent cations, decreased negative adsorption of ions, and the increased solution of gypsum and alkaline-earth carbonates (*2*).

The water retention characteristic of a soil must be considered in appraising the soluble salt content. An ideal method would consist of measuring the salt concentration of an extract obtained at field-water content, but the difficulty of obtaining such an extract prohibits its routine use. An extract made at a higher water content has been proved to be satisfactory in following changes in the salt content with time or treatment (*2*).

Procedure: The method used for the determination of water-soluble salts in soils is a modification of the procedure described in the Official Methods of Analysis of the Association of Official Agricultural Chemists (*1*). Soluble salts in a sample of soil are extracted with distilled water and the total dissolved solids are determined gravimetrically.

A 50-gram sample of soil is placed in a 250-milliliter Erlenmeyer flask. One hundred and twenty-five milliliters of distilled water are added, and the soil and water suspension is agitated for 30 minutes on a mechanical shaking machine. The suspension is allowed to stand overnight and filtered through a Pasteur-Chamberlain filter. A 50-milliliter aliquot of the filtrate is placed in a porcelain or platinum evaporating dish that has been previously heated, cooled in a desiccator, and weighed. The evaporating dish containing the filtrate is placed in an oven and allowed to dry. The residue is then ignited with a Fisher Burner at a very low heat to remove the organic matter. The evaporating dish containing the soluble salts is cooled and placed in a desiccator and weighed. The difference between the weight of the dish and the weight of the dish plus the ignited residue is the weight of the salts that have been extracted from 20 grams of soil.

Comments: According to Jackson (*9*), the gravimetric method for the determination of dissolved solids affords a direct measure of total salinity and serves as a check on the results by the more rapid electrical conductance methods.

Prolonged heating to remove organic matter should be avoided because of losses of salts, particularly magnesium chloride.

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The Relationship of Sugar Cane Yields To the Phosphorus and Sulphur Contents Of Certain Louisiana Soils

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The Relationship of Sugar Cane Yields To the Phosphorus and Sulphur Contents Of Certain Louisiana Soils

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LARON E. GOLDEN[1]

INTRODUCTION

Results obtained in experiments with sugar cane in Louisiana where normal superphosphate was used suggest the need for more knowledge concerning phosphorus (P) and sulphur (S) in soils planted to sugar cane and the relationship between the P and S status of the soil and yields of sugar cane as influenced by additions of normal superphosphate. Normal superphosphate contains an average of 8.7 per cent P (equivalent to 20 per cent P_2O_5) and 11.9 per cent S. In Louisiana, the S content of sugar cane was found to be approximately equal to the P content when P and S were applied as normal superphosphate (*13*).[2]

The primary purpose of this study was to determine the relationship of differences in yields obtained from check (control) and normal superphosphate treatments to extractable P and to soluble S in soils cropped to sugar cane.

Phosphorus

Some relationships of differences in sugar cane yields obtained from check and normal superphosphate treatments to soil P and its fractions have been reported by Byrnside and Sturgis (*5*). The work by Byrnside and Sturgis was accomplished in Louisiana from 1954 through 1957. In this work, topsoils were shown to contain an average of 529 ppm of total P. Subsoils contained an average of 482 ppm of total P.

Several soil studies have been conducted in Louisiana (*5, 9, 10, 11, 12, 21, 22*) which were concerned with the availability of P as determined by different methods. Standardizations of chemical methods for extracting soil P as bases for recommendations for applications of fertilizer P to sugar cane have been reported by several workers (*1, 5, 6, 15, 19*).

Sulphur

Most of the S in field soils in humid regions is associated with organic compounds (*2, 4, 17*). The total S in most field soils varies from 100 to 500 ppm (*4*).

Bardsley and Lancaster (*2*) have defined "Soil" S as being the combined organic, oxidizable inorganic, and soluble sulphate S in soils. Since their method does not involve fusion, sulphate compounds such as insoluble $BaSO_4$, and S occluded by soil minerals against extraction after ignition at 500° C., may not be determined to an appreciable extent. They reported the mean "Soil" S content of 23 surface soils to be 198 pounds per acre, and the sulphate S content to be 19 pounds per acre.

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[1] Department of Agronomy.

[2] Italic numbers in parentheses refer to Literature Cited, Page 20.

Ammonium sulphate is the source of fertilizer nitrogen (N) for sugar cane in many areas of the world. Due to the use of ammonium sulphate and other fertilizers containing S, there previously has been little practical need for research related to S as an applied nutrient for sugar cane.

Bonnet (*3*) reported that he found S to be responsible for significant yield responses by sugar cane in Puerto Rico in 1964. In Louisiana in 1967 (*7*), the use of S at the rate of 24 pounds per acre resulted in sugar cane and sugar yield increases which were statistically significant. The sugar cane and sugar yield increases were 1.67 net tons per acre and 570 pounds per acre, respectively. In five other experiments conducted in Louisiana in 1966 and 1967 (*7, 8*), yield differences due to use of 24 pounds of S per acre, when considered in individual experiments, were statistically non-significant. Collection of more yield data is required before statistical analysis of all yield data as a group will be of practical value.

Hoover (*14*) reported that generally there are small quantities of both total and organic S in soils of the state of Mississippi. He further stated that farm operators can no longer rely on incidental additions of S from rainwater, the atmosphere, insecticides, and ordinary mixed fertilizers for maintenance of high yields.

No published information has been found indicating attempts to correlate the S content of soils of the sugar cane producing area of Louisiana with yields of sugar cane. Sugar cane growers in Louisiana have applied less S in fertilizers in recent years due to increased use of liquid fertilizers containing no S and high-analysis fertilizers containing relatively small amounts of S.

EXPERIMENTAL

Soils, Soil Material, and Yield Data

A description of soil types in the sugar cane producing area of Louisiana has been made by Lytle and Sturgis (*18*).

During the 9-year period, 1958-66, soil samples and yield data were collected from 50 fertilizer experiments with sugar cane at 29 locations in Louisiana's sugar cane producing area.

The fertilizer treatments in the experiments were replicated three times in a randomized block design. The plot size was approximately one-tenth acre. The fertilizer materials used were ammonium nitrate, normal superphosphate, and muriate of potash. Fertilizers were applied in the off-bar furrow in the spring at a depth of approximately 6 inches.

Yields obtained from sugar cane fertilized with normal superphosphate fertilizer, used at the rate of 200 pounds per acre, were compared with yields from check plots. The yields which were compared were from N-P and N-P-K treatments versus N and N-K treatments. Since yield differences obtained from check and normal superphosphate treatments were less from coarser-textured soils than from finer-textured soils, the coarser-textured soils are separated from finer-textured soils in discussion of the results.

Topsoil and subsoil samples were taken at each experimental location in the spring when the experiment, or series of experiments, was initiated.

Soil Analysis Procedures

Soil samples were composited, air-dried, and passed through a 2-mm. sieve. Total N was determined by the Kjeldahl method (*16*). Organic carbon (C) was determined by the dry combustion method (*20*). "Soil" S and soluble S were determined by the method of Bardsley and Lancaster (*2*). Soil samples were digested by use of hydrofluoric acid for total P determinations. Extractable P was obtained by use of the following seven chemical procedures.

Procedure no.	Extractant	Extractant-to-soil ratio	Minutes shaken	pH of extractant
1	0.025 N HCl + 0.03 N NH_4F	20	20	2.8
2	0.05 N HCl + 0.03 N NH_4F	20	20	1.9
3	0.014 N HCl	20	20	1.9
4	0.1 N HCl + 0.03 N NH_4F	20	20	1.3
5	0.05 N HCl	20	20	1.4
6	0.1 N HCl	10	20	1.0
7	0.1 N HCl	20	20	1.0

The amounts of P in solutions prepared for total P determinations and the amounts of P in soil extracts were determined by the chlorostannous-reduced molybdophosphoric blue color method in hydrochloric acid system (*16*).

The pH values from soil samples and extracting solutions were obtained by use of a Beckman Zeromatic pH meter.

Laboratory analytical work was accomplished with solutions maintained at a temperature of 25° C. (*9*).

Terminology

Reference to "yield response," used by many authors when discussing effects of fertilizers on crops, is replaced in this report with the general expression "differences in yields obtained from check and normal superphosphate treatments."

RESULTS AND DISCUSSION

The locations and soil types where the fertilizer experiments were conducted are shown in Table 1. Thirty experiments were conducted at 19 locations (Nos. 1-19) on alluvial soils of the Mississippi and Red River flood plains. Twenty experiments were conducted at 10 locations (Nos. 20-29) on older alluvial or Mississippi River terrace soils in the western part of the sugar cane producing area.

Phosphorus

Table 2 contains data obtained from analyses of topsoil samples for total P and for P extracted by use of seven different chemical procedures.

TABLE 1.—Soil Types and Locations of Experiments on Alluvial Soils (Nos. 1-19) and Older Alluvial or Terrace Soils (Nos. 20-29)

Location no.	Soil type	Plantation	Year of experiment: Plant cane	First stubble	Second stubble	
		Alluvial soils				
1	Yahola sil	Edgefield	1959			
2	Yahola sil	Meeker		1965		
3	Commerce sil	Alma	1962	1963		
4	Commerce sil	Smithfield	1959	1960		
5	Commerce sil	Smithfield		1964		
6	Commerce sil	Myrtle Grove		1965		
7	Mhoon sil	Smithfield		1958		
8	Mhoon sil	Little Texas	1960	1961	1962	
9	Mhoon sil	Little Texas		1958	1959	
10	Mhoon sil	Little Texas	1964			
11	Mhoon sil	Laurel Ridge		1965		
12	Mhoon sil	Georgia		1963		
13	Mhoon sicl	Smithfield		1965		
14	Mhoon sicl	Laurel Grove		1963	1964	1965[1]
15	Mhoon sicl	Laurel Grove		1966		
16	Mhoon sicl	F. A. Gaugnard		1964		
17	Mhoon sicl	Pecan Tree		1960	1961	
18	Sharkey c	Pecan Tree	1962	1963		
19	Sharkey c	Pecan Tree		1964	1965	1966[1]
		Older alluvial or terrace soils				
20	Richland sil	Young's Industries	1963			
21	Olivier sil	Young's Industries	1959	1960	1961	
22	Jeanerette sil	Alice "B"	1959			
23	Jeanerette sil	M. A. Patout & Son		1961		
24	Jeanerette sil	M. A. Patout & Son	1962	1963		
25	Jeanerette sil	M. A. Patout & Son	1965			
26	Jeanerette sil	St. John	1963	1964	1965	
27	Baldwin sil	Alice "B"	1962	1963		
28	Baldwin sic	O'Neil	1958	1959	1960	
29	Baldwin sic	O'Neil	1963	1964	1965	

[1] Third stubble.

The total P content of the alluvial soils varied from 423 ppm in Yahola silt loam to 909 ppm in Mhoon silty clay loam, and averaged 607 ppm. The total P content of the older alluvial or terrace soils varied

TABLE 2.—Phosphorus Content of Topsoil Samples from Alluvial Soils (1-19) and Older Alluvial or Terrace Soils (20-29)

Location no.	Total	Extractable phosphorus, ppm Chemical procedure[1] No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
				Alluvial soils				
1	468	21	104	129	241	235	240	309
2	423	20	85	99	192	158	183	249
3	504	39	105	150	237	213	217	266
4	523	19	121	175	299	266	269	333
5	519	60	171	214	343	298	362	418
6	677	48	145	162	285	250	268	332
7	465	31	175	233	366	355	352	434
8	619	18	70	130	233	196	188	260
9	652	21	74	136	216	189	185	245
10	503	25	93	136	230	204	210	255
11	528	22	92	127	233	186	196	250
12	493	26	60	82	181	127	116	177
13	811	56	148	167	327	242	224	275
14	909	90	146	152	336	212	186	286
15	724	54	123	147	278	212	219	267
16	531	25	46	47	136	85	88	122
17	485	30	85	129	242	188	177	245
18	840	106	189	174	362	233	211	305
19	867	151	228	226	469	294	277	367
Averages:	607	45	119	148	274	218	219	284
				Older alluvial or terrace soils				
20	289	11	13	1	14	2	2	4
21	532	53	59	8	68	15	15	22
22	390	32	55	54	105	97	94	119
23	576	127	365	241	451	337	353	430
24	504	77	157	110	178	134	119	158
25	482	29	55	42	91	67	76	109
26	317	53	76	62	132	90	85	117
27	314	14	36	52	82	82	78	100
28	452	20	21	3	30	7	7	10
29	479	39	49	11	60	22	23	30
Averages:	433	45	89	58	121	85	85	110

[1] No. 1: 0.025 N HCl + 0.03 N NH_4F, pH = 2.8. Soil-to-extractant ratio, 1 to 20.
No. 2: 0.05 N HCl + 0.03 N NH_4F, pH = 1.9. Soil-to-extractant ratio, 1 to 20.
No. 3: 0.014 N HCl, pH = 1.9. Soil-to-extractant ratio, 1 to 20.
No. 4: 0.1 N HCl + 0.03 N NH_4F, pH = 1.3. Soil-to-extractant ratio, 1 to 20.
No. 5: 0.05 N HCl, pH = 1.4. Soil-to-extractant ratio, 1 to 20.
No. 6: 0.1 N HCl, pH = 1.0. Soil-to-extractant ratio, 1 to 10.
No. 7: 0.1 N HCl, pH = 1.0. Soil-to-extractant ratio, 1 to 20.

from 289 ppm in Richland silt loam to 576 ppm in Jeanerette silt loam, and averaged 433 ppm.

Chemical procedures are outlined in a footnote to Table 2. Procedures Nos. 1, 2, and 4, Table 2, varied only in the amounts of HCl in the extractant and in the effect of HCl on pH. With these procedures increased amounts of P were extracted at each location as the amount of HCl increased or as the pH was lowered. The averages of P extracted from alluvial soils with procedures Nos. 1, 2, and 4 were 45, 119, and 274 ppm, respectively. The averages of P extracted from older alluvial or terrace soils with procedures Nos. 1, 2, and 4 were 45, 89, and 121 ppm, respectively.

The extractant for chemical procedure No. 3, containing only HCl, was developed to compare results with the extractant for procedure No. 2, which contained both HCl and NH_4F. The pH of the extractant used in procedure No. 2 was found to be 1.9, and the pH of the extractant used in procedure No. 3 was adjusted with HCl to 1.9 in order that the hydrogen ion activity of the two extractants would be identical. From the data in Table 2, it can be seen that use of chemical procedure No. 3 generally resulted in higher amounts of P being extracted from alluvial soils and lower amounts from older alluvial or terrace soils than the amounts resulting from the use of chemical procedure No. 2. The higher amounts of P extracted from alluvial soils by use of procedure No. 3 indicate that the NH_4F buffered the P obtained in procedure No. 2 and/or that some other reaction of an indeterminate nature may have occurred. The higher amounts of P extracted by procedure No. 2 from older alluvial or terrace soils indicate a preponderance of P in forms differing considerably from those in the alluvial soils (*5*).

In chemical procedure No. 6, the soil-to-extractant ratio used was 1 to 10. This ratio was used in order that the amount of active hydrogen in the 0.1 N HCl extractant per unit weight of soil sample would approximate the active hydrogen per unit weight of soil sample in chemical procedure No. 5. In procedure No. 5, a 0.05 N HCl extractant was used at a soil-to-extractant ratio of 1 to 20. A comparison of results obtained with procedures No. 5 and No. 6 shows very close agreement between P values.

Results obtained with procedure No. 7 were compared with those from procedure No. 4. The amount of HCl used in each extractant was constant (0.1 N) but, additionally, the extractant used in procedure No. 4 was 0.03 N with respect to NH_4F. Since the pH of the extractant used in procedure No. 4 was 1.3, and the pH of the extractant used in procedure No. 7 was 1.0, it is evident that the NH_4F resulted in a buffering of the hydrogen ions in the extractant used in procedure No. 4. The comparison revealed moderately close agreement between P values obtained.

Byrnside and Sturgis (*5*) reported that the forms of P extractable from alluvial soils apparently were largely calcium phosphates. They also indicated that inorganic P in Richland and Olivier soils occurred as the less soluble or "adsorbed" forms of P. These forms were considered to be iron or aluminum phosphates, phosphates bound or adsorbed on the surface of hydrated iron or aluminum oxides, and phosphates adsorbed on clay surfaces. The results obtained from the chemical procedures used in this study are in general agreement with the findings of Byrnside and Sturgis (*5*).

Phosphorus Correlations

The differences in yields of sugar cane obtained from check and normal superphosphate treatments are shown in Table 3. Simple correlation coefficients and coefficients of multiple correlation were obtained from analysis of total P and of extractable P values, by different chemical procedures (Table 2), and differences in yields obtained from check and normal superphosphate treatments (Table 3). In all cases, when all of the data were considered together, correlation coefficients were nonsignificant or were too low to be of importance for yield-prediction purposes.

Table 4 contains results from statistical analyses following groupings of yield data and corresponding chemical data. Group I consists of plant cane and only that stubble cane which was grown on coarser-textured soils. Group II is composed of first stubble cane grown on finer-textured

TABLE 3.—Differences in Yields of Sugar Cane Obtained from Check and Superphosphate Treatments on Alluvial Soils (Nos. 1-19) and Older Alluvial or Terrace Soils (Nos. 20-29)

Location no.	Plant cane	First stubble	Second stubble	Location no.	Plant cane	First stubble	Second stubble	
	T/A.	T/A.	T/A.		T/A.	T/A.	T/A.	
				Alluvial soils				
1	-0.28	—	—	11	—	0.82	—	
2	—	0.86*	—	12	—	2.59**	—	
3	-0.27	-0.01	—	13	—	1.81*	—	
4	-0.07	0.01	—	14	—	1.30	3.30**	2.97[1]**
5	—	-0.80	—	15	—	1.79*	—	
6	—	0.62	—	16	—	0.56	—	
7	—	0.55	—	17	—	0.87	1.91**	
8	0.40	1.40**	0.99	18	—	1.49*	—	
9	—	1.72**	3.37**	19	—	0.53	0.50	0.27[1]
10	-0.60	—	—					
				Older alluvial or terrace soils				
20	0.53	—	—	25	1.07	—	—	
21	1.02	1.08	1.86*	26	-0.23	0.87	1.35	
22	-0.07	—	—	27	1.21	1.14	—	
23	—	-0.03	—	28	1.35*	2.05*	4.01*	
24	-0.13	1.18	—	29	1.61	2.00*	4.48*	

[1] Third stubble.

* Significant at the 5% level of probability.

** Significant at the 1% level of probability.

TABLE 4.—Correlation Coefficients (r) and Linear Regression Equations for the Relationship Between Extractable P Values (X) Obtained by Different Chemical Procedures and Differences in Yields Obtained from Check and Superphosphate Treatments (Y)

Chemical procedure no.	Correlation coefficients (r)	Linear regression equations
Group I: Plant cane and stubble cane on coarser-textured soils		
1	−0.228	Y = 0.06 − 0.0088X
2	−0.633**	Y = 1.19 − 0.0099X
3	−0.722**	Y = 1.07 − 0.0075X
4	−0.696**	Y = 1.18 − 0.0048X
5	−0.710**	Y = 1.08 − 0.0050X
6	−0.670**	Y = 1.04 − 0.0045X
7	−0.681**	Y = 1.05 − 0.0037X
Group II: First stubble cane on finer-textured soils		
1	−0.393	Y = 1.59 − 0.0064X
2	−0.542*	Y = 1.73 − 0.0042X
3	−0.439	Y = 1.70 − 0.0038X
4	−0.427	Y = 1.74 − 0.0021X
5	−0.439	Y = 1.72 − 0.0028X
6	−0.473*	Y = 1.74 − 0.0030X
7	−0.445*	Y = 1.74 − 0.0023X
Group III: Second and third stubble cane on finer-textured soils		
1	−0.531	Y = 3.28 − 0.0154X
2	−0.595*	Y = 3.58 − 0.0122X
3	−0.591*	Y = 3.45 − 0.0105X
4	−0.587*	Y = 3.55 − 0.0054X
5	−0.583*	Y = 3.51 − 0.0079X
6	−0.362	Y = 3.55 − 0.0087X
7	−0.559	Y = 3.48 − 0.0060X

*Significant at the 5% level of probability.
**Significant at the 1% level of probability.

soils, and Group III is composed of second and third stubble cane grown on finer-textured soils. Yahola silt loam and Commerce silt loam soils were classed as "coarser" soils due to their greater depth of relatively coarse soil material and to the relatively high proportion of sugar cane roots which permeate horizons below the topsoil.

Simple correlation coefficients (r) and linear regression equations for the relationship between P values (X), and differences in yields (Y), are shown in Table 4. Data from chemical procedures No. 2, No. 4, and No. 7 are shown graphically in Figures 1 through 9.

The data in Table 4 show that chemical procedure No. 2 was the only procedure which resulted in a significant or highly significant correlation between P in the extract and differences in yields obtained from check and normal superphosphate treatments in each of the three groups of sugar cane studied. Chemical procedure No. 1 was the only procedure used which did not result in at least one significant correlation. Chemical procedure No. 3 was superior to No. 2 in Group I, was inferior to No. 2

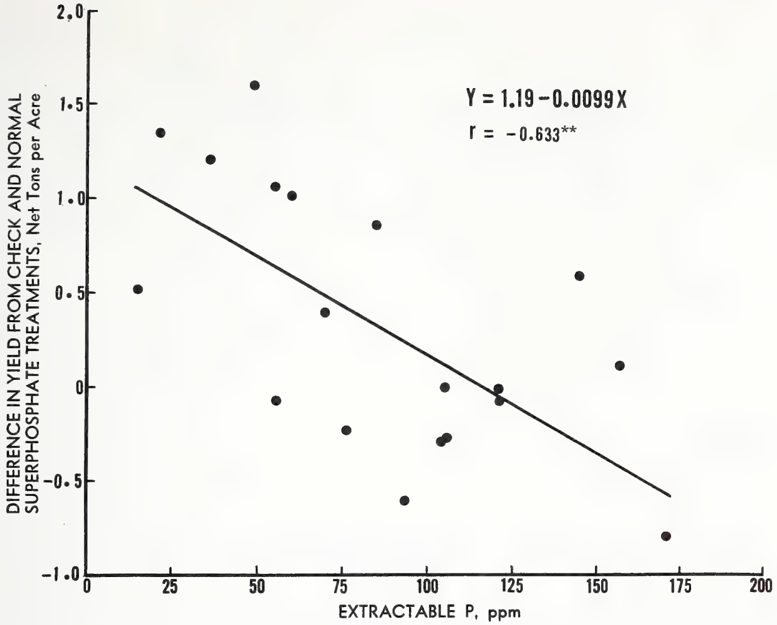

FIGURE 1.—Relationship between P extracted with 0.05 N HCl + 0.03 N NH_4F and differences in yields obtained from check and normal superphosphate treatments of plant cane and stubble cane on coarser-textured soils.

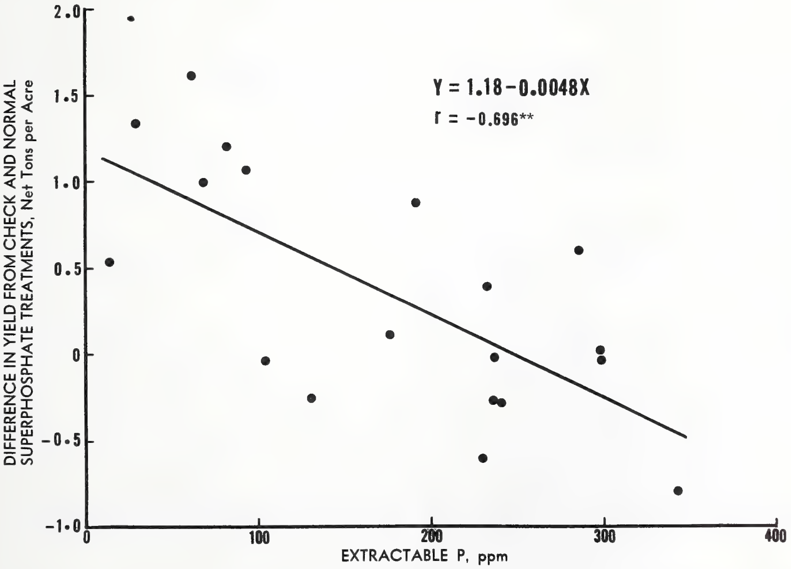

FIGURE 2.—Relationship between P extracted with 0.1 N HCl + 0.03 N NH_4F and differences in yields obtained from check and normal superphosphate treatments of plant cane and stubble cane on coarser-textured soils.

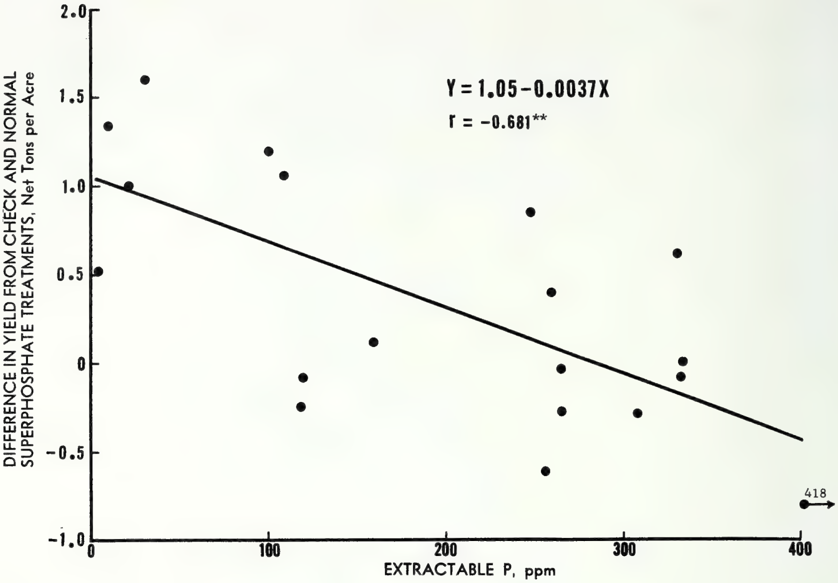

FIGURE 3.—Relationship between P extracted with 0.1 N HCl and differences in yields obtained from check and normal superphosphate treatments of plant cane and stubble cane on coarser-textured soils.

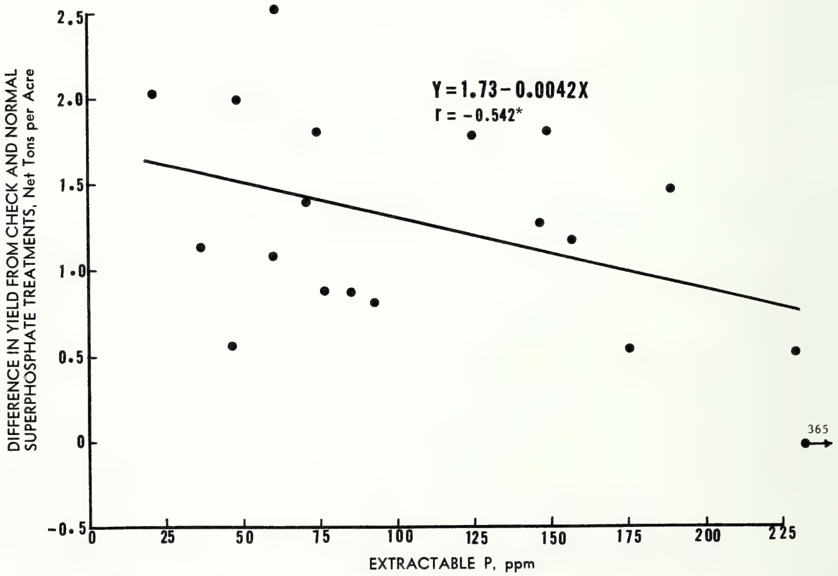

FIGURE 4.—Relationship between P extracted with 0.05 N HCl + 0.03 N NH_4F and differences in yields obtained from check and normal superphosphate treatments of first stubble cane on finer-textured soils.

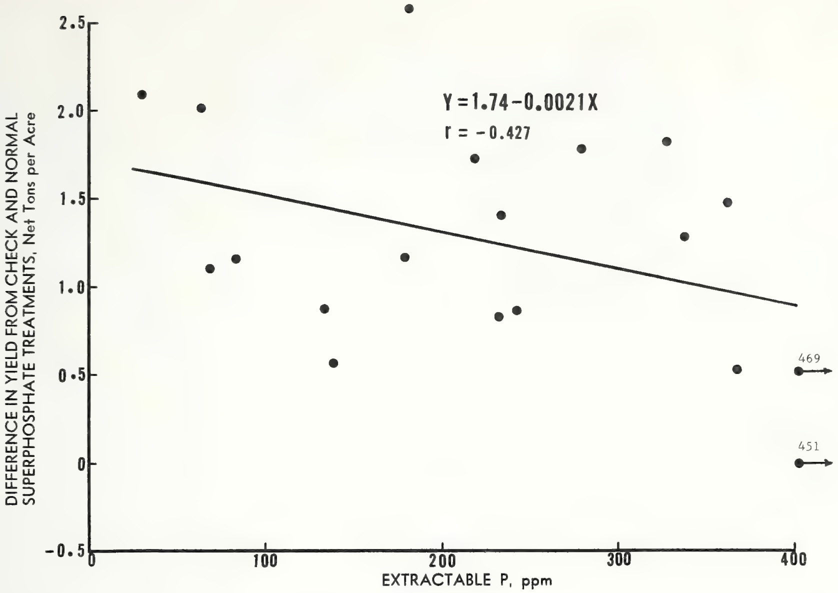

FIGURE 5.—Relationship between P extracted with 0.1 N HC1 + 0.03 N NH_4F and differences in yields obtained from check and normal superphosphate treatments of first stubble cane on finer-textured soils.

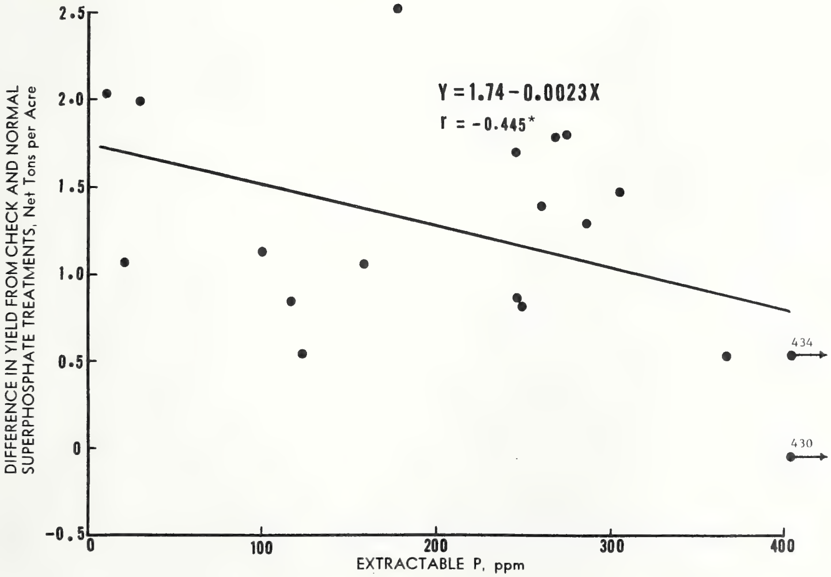

FIGURE 6.—Relationship between P extracted with 0.1 N HC1 and differences in yields obtained from check and normal superphosphate treatments of first stubble cane on finer-textured soils.

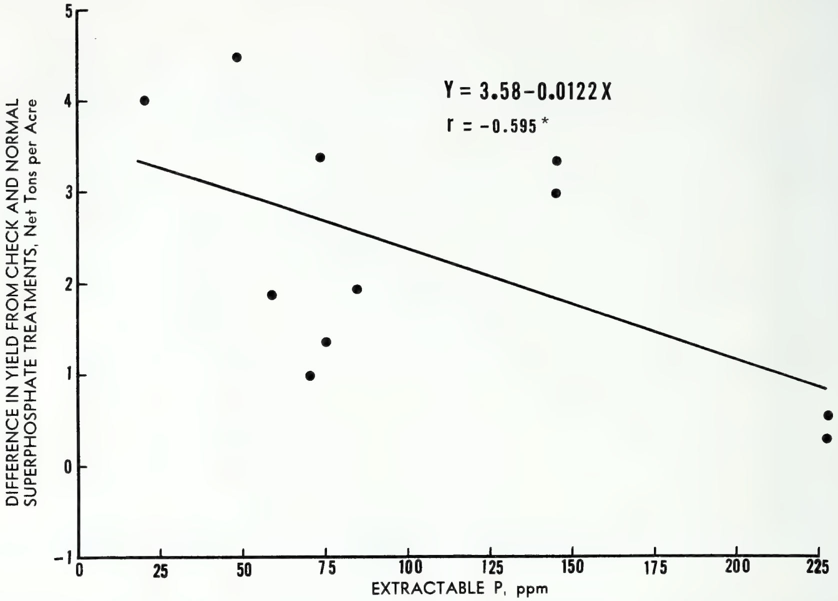

FIGURE 7.—Relationship between P extracted with 0.05 N HCl + 0.03 N NH_4F and differences in yields obtained from check and normal superphosphate treatments of second and third stubble cane on finer-textured soils.

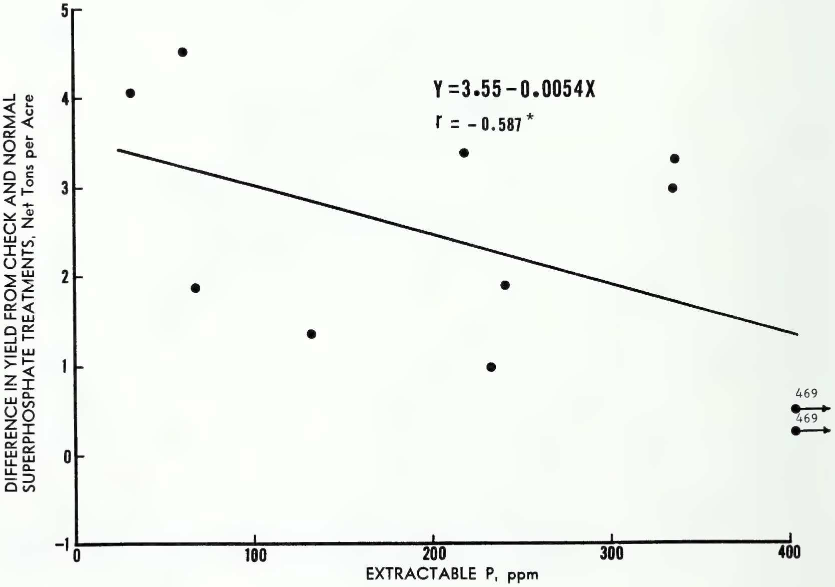

FIGURE 8.—Relationship between P extracted with 0.1 N HCl + 0.03 N NH_4F and differences in yields obtained from check and normal superphosphate treatments of second and third stubble cane on finer-textured soils.

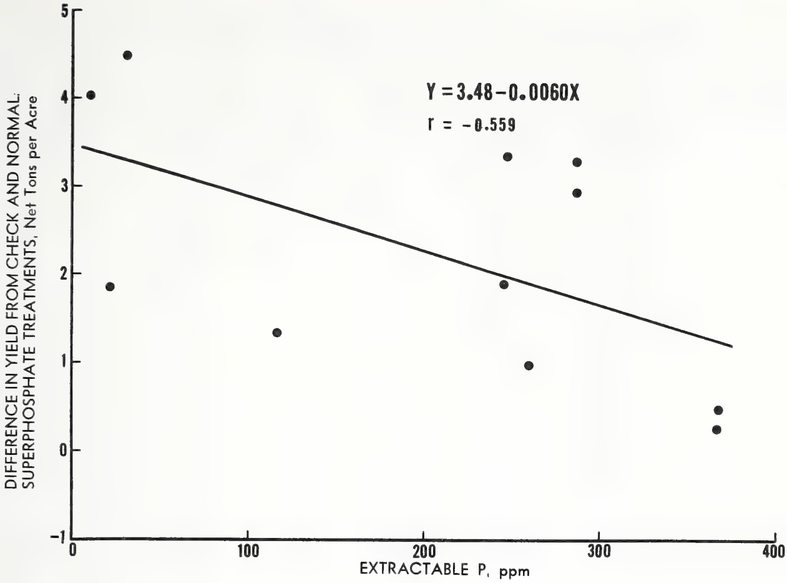

FIGURE 9.—Relationship between P extracted with 0.1 N HCl and differences in yields obtained from check and normal superphosphate treatments of second and third stubble cane on finer-textured soils.

in Group II, and was approximately equal to No. 2 in Group III. The data indicate that for practical purposes chemical procedure No. 4, the method presently used in the Louisiana Agricultural Experiment Station Soil Testing Laboratory for extracting P, is satisfactory as a basis for recommending use of normal superphosphate in a fertilization program for sugar cane in Louisiana. Likewise, for practical purposes, chemical procedure No. 7, the method presently used in the Soil Testing Laboratory for extraction of bases, is satisfactory for extracting P.

From the points on the graphs in Figures 1, 2, and 3 it can be seen that a yield difference between check and normal superphosphate treatments averaging about 1 ton per acre was obtained from plant cane and stubble cane on coarser-textured soils when extractable P values were below 50, 100, and 110 ppm for chemical procedures No. 2, No. 4, and No. 7, respectively. In Figures 4, 5, and 6 it may be noted that an average difference of about 1.5 tons per acre was obtained from first stubble cane on finer-textured soils when extractable P values were below 175, 350, and 320 ppm for chemical procedures No. 2, No. 4, and No. 7, respectively. The points in Figures 7, 8, and 9 show an average difference of about 2.5 tons per acre from second and third stubble cane on finer-textured soils when extractable P values were below 220, 400, and 350 ppm for chemical procedures No. 2, No. 4, and No. 7, respectively.

TABLE 5.—Organic Carbon, Nitrogen and Sulphur Contents and pH of Alluvial Soils (Nos. 1-19) and Older Alluvial or Terrace Soils (Nos. 20-29)

Sample no. and horizon[1]		Orangic carbon	Total nitrogen	Carbon: nitrogen ratio	Sulphur		Nitrogen: "Soil" sulphur ratio	pH
					"Soil"	soluble		
		%	%		ppm	ppm		
				Alluvial soils				
1	A	0.469	0.041	11.4	135	9.1	3.0	7.3
	B	0.438	0.048	9.1	177	36.2	2.7	7.8
2	A	0.800	0.076	10.5	110	5.2	6.9	7.1
	B	0.329	0.036	9.1	72	6.2	5.0	7.7
3	A	0.684	0.064	10.7	146	4.9	4.4	5.6
	B	0.438	0.049	8.9	131	4.3	3.7	6.5
4	A	0.754	0.067	11.3	200	6.1	3.4	6.9
	B	0.339	0.034	10.0	129	6.4	2.6	7.4
5	A	0.557	0.057	9.8	158	3.1	3.6	6.7
	B	0.478	0.043	11.1	133	4.3	3.2	7.3
6	A	0.752	0.077	9.8	101	11.2	7.6	5.8
	B	0.368	0.036	10.2	66	7.2	5.5	6.6
7	A	0.653	0.064	10.2	148	5.1	4.3	6.7
	B	0.481	0.045	10.7	169	7.4	2.7	7.2
8	A	0.793	0.068	11.7	148	4.8	4.6	6.7
	B	0.478	0.043	11.1	137	6.2	3.1	7.4
9	A	0.680	0.066	10.3	173	5.2	3.8	6.1
	B	0.410	0.050	8.2	136	6.4	3.7	6.3
10	A	0.853	0.083	10.3	112	4.6	7.4	6.0
	B	0.561	0.056	10.0	93	5.9	6.0	7.4
11	A	0.818	0.071	11.5	119	3.2	6.0	6.2
	B	0.580	0.064	9.1	89	3.2	7.2	7.0
12	A	0.812	0.086	9.4	225	5.2	3.8	5.7
	B	0.489	0.057	8.6	135	6.2	4.2	6.6
13	A	1.060	0.088	12.0	166	4.9	5.3	6.1
	B	0.875	0.099	8.8	137	4.1	7.2	6.6
14	A	1.317	0.105	12.5	259	4.5	4.1	6.2
	B	0.610	0.070	8.7	179	7.0	3.9	6.3
15	A	1.071	0.093	11.5	122	3.4	7.6	6.1
	B	0.653	0.064	10.2	116	2.9	5.5	6.2
16	A	1.334	0.142	9.4	272	3.8	5.2	5.9
	B	1.035	0.112	9.2	228	8.7	4.9	6.2
17	A	1.104	0.095	11.6	230	5.5	4.1	6.4
	B	0.534	0.060	8.9	181	6.2	3.3	7.1
18	A	2.123	0.175	12.1	387	8.0	4.5	6.6
	B	0.909	0.092	9.9	209	7.0	4.4	7.0
19	A	1.781	0.169	10.5	357	4.3	4.7	6.5
	B	1.195	0.109	11.0	267	7.9	4.1	7.0

(Continued)

TABLE 5.—(Continued) Organic Carbon, Nitrogen and Sulphur Contents and pH of Alluvial Soils (Nos. 1-19) and Older Alluvial or Terrace Soils (Nos. 20-29)

Sample no. and horizon[1]	Organic carbon	Total nitrogen	Carbon: nitrogen ratio	Sulphur "Soil"	Sulphur soluble	Nitrogen: "Soil" sulphur ratio	pH
	%	%		ppm	ppm		
		Older alluvial or terrace soils					
20 A	0.870	0.098	8.9	148	20.4	6.6	4.6
B	0.612	0.073	8.4	83	27.6	8.8	4.6
21 A	1.147	0.115	10.0	132	12.0	8.7	5.5
B	0.600	0.077	7.8	157	17.6	4.9	4.5
22 A	1.291	0.114	11.3	221	10.6	5.2	6.8
B	0.497	0.048	10.4	137	10.2	3.5	7.6
23 A	1.717	0.131	13.1	313	10.2	4.2	7.1
B	0.792	0.073	10.8	181	10.0	4.0	7.7
24 A	1.404	0.114	12.3	224	5.9	5.1	6.7
B	1.081	0.083	13.0	112	4.0	7.4	6.8
25 A	1.277	0.107	11.9	151	6.2	7.1	6.5
B	1.307	0.112	11.7	152	10.1	7.4	7.5
26 A	0.916	0.110	8.3	197	6.3	5.6	7.0
B	0.616	0.057	10.8	171	33.2	3.3	7.7
27 A	0.899	0.071	12.7	158	6.1	4.5	7.1
B	0.606	0.050	12.1	86	4.4	5.8	7.7
28 A	1.325	0.125	10.6	180	11.4	6.9	4.8
B	0.572	0.070	8.2	103	6.7	6.8	4.6
29 A	1.125	0.097	11.6	124	11.1	7.8	4.8
B	0.773	0.079	9.8	74	9.5	10.7	4.7

[1] Topsoil or A horizon samples were generally taken from depths down to 8 to 10 inches. B horizon samples were obtained below A horizon samples, generally to a depth of 20 to 24 inches.

Sulphur Content and Other Soil Properties

The data showing "Soil" S and soluble S, organic C, total N, and pH are shown in Table 5. The average C/N ratio found in the A horizon was 10.9. In the B horizon the average C/N ratio was 9.9. Corresponding C/N ratios from similar soil types obtained by Byrnside and Sturgis (*5*) were 10.8 and 9.6. In the A horizon the pH varied from 4.6 in Richland silt loam to 7.3 in Yahola silt loam, and in the B horizon it varied from 4.5 in Olivier silt loam to 7.8 in Yahola silt loam.

"Soil" Sulphur

"Soil" S in the A horizon (Table 5) varied from 101 ppm in Commerce silt loam to 387 ppm in Sharkey clay and averaged 187 ppm. "Soil" S in the B horizon varied from 66 ppm in Commerce silt loam to 267 ppm in Sharkey clay and averaged 139 ppm.

The average total N/"Soil" S ratio found in the A horizon was 5.4, and in the B horizon it was 5.0. Bardsley and Lancaster (*2*) reported a total N/"Soil" S ratio for 23 surface soils to be 8.2.

Soluble Sulphur

Soluble S found in the A horizon by the method of Bardsley and Lancaster (*2*) varied from 3.1 ppm in Commerce silt loam to 20.4 ppm in Richland silt loam, and averaged 7.0 ppm. Soluble S in the B horizon varied from 2.9 ppm in Mhoon silty clay loam to 36.2 ppm in Yahola silt loam and averaged 9.6 ppm. The high soluble S values obtained from B horizon samples No. 1, No. 20, and No. 26 (Table 5) appear to reflect a history of the use of S in low analysis complete fertilizers and in normal superphosphate.

Sulphur Correlations

Simple correlation coefficients and coefficients of multiple correlations were obtained between "Soil" S and soluble S values (Table 5) and differences in yields obtained from check and normal superphosphate treatments (Table 3). The data were analyzed as one group and as three separate groups in the same manner as was used with extractable P. In no case was a significant correlation found between "Soil" S or soluble S and differences in yields obtained from sugar cane grown on check and normal superphosphate treatments.

Discussion

Sugar cane yield increases due to applied normal superphosphate were generally progressive throughout the cycle of plant and stubble crops and were of the order: plant cane $<$ first stubble $<$ second stubble. Previous work (*9*) revealed that availability of P to sugar cane was regressive throughout the cycle of plant and stubble crops. The lower amounts of P available in soils to successive crops of sugar cane within a cycle of crops provide partial explanation for differences in yield increases obtained.

There is no direct method to evaluate possible residual benefit from use of normal superphosphate in the experiments reported in Table 3. Likewise, the effect of S in normal superphosphate on yield differences reported cannot be directly evaluated. If correlations of yield differences with P and S values obtained from soil analyses are the only criteria considered, the results obtained indicate that P was the dominant factor in normal superphosphate which influenced yield.

The S content is approximately equal to the P content of sugar cane in Louisiana (*13*). It was found to be less than the P content when no S was supplied in fertilizers and was sometimes greater than the P content when S was supplied in fertilizers.

The relative amount of S absorbed by sugar cane in Louisiana is much greater than P, when both P and S are supplied by fertilizers (*8*). The relative uptake of P and S is apparently associated with their relative solubility in fertilizers, rate of release from organic matter, mobility, and total amounts in soils. Sugar cane requirements for P and S from soils and fertilizers may differ considerably from the relative uptake of the two nutrients.

SUMMARY AND CONCLUSIONS

A study was made of the relationship of differences in sugar cane yields obtained from check and normal superphosphate treatments to P and S contents of soils in Louisiana.

The differences in yields of sugar cane obtained from check and normal superphosphate treatments were generally of the order: plant cane $<$ first stubble $<$ second stubble. Differences were generally greater on finer-textured soils than on coarser-textured soils. The greater differences between yields from check and normal superphosphate treatments on finer-textured soils were apparently due to restricted aeration and root penetration which resulted in relatively greater feeding on applied normal superphosphate fertilizer.

Simple correlation coefficients and coefficients of multiple correlation were obtained from analyses of extractable P values obtained by seven different chemical procedures and differences in yields from check and normal superphosphate treatments. In all cases, when all differences in yields and corresponding extractable P data were considered together, correlation coefficients were non-significant or were too low to be of importance for yield-prediction purposes. Several significant and highly significant correlations were found when the differences in yields and corresponding chemical data were studied in three groupings: (1) plant cane and stubble cane on coarser-textured soils, (2) first stubble cane on finer-textured soils, and (3) second and third stubble cane on finer-textured soils.

The chemical procedure which included the use of an extracting solution of 0.05 N HCl + 0.03 N NH_4F was the only one resulting in a significant correlation between extractable P and differences in yields in each of the three groups studied. By use of this procedure extractable P in the A horizon varied from 11 ppm to 151 ppm. The procedures which included the use of an extracting solution of 0.1 N HCl + 0.03 N NH_4F or 0.1 N HCl were found to result in extractable P values which correlated with yield differences to an adequate degree for yield-prediction purposes.

Total P in the A horizon varied from 289 ppm to 909 ppm.

"Soil" S in the A horizon varied from 101 ppm to 387 ppm, and in the B horizon it varied from 66 ppm to 267 ppm. The average total N/"Soil" S ratio in the A horizon was 5.4, and in the B horizon it was 5.0. Soluble S in the A horizon varied from 3.1 ppm to 20.4 ppm, and in the B horizon it varied from 2.9 ppm to 36.2 ppm. Statistical analyses resulted in no significant correlations between soluble S and differences in yields of sugar cane obtained from check and normal superphosphate treatments.

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Dehydrated Pellets for Fattening Steers

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Dehydrated Pellets for Fattening Steers

T. Wayne White[1]

Gulf ryegrass and Sudangrass grow well in southwest Louisiana. They respond favorably to nitrogen fertilizer, producing high yields with increased crude protein content when thus fertilized. Both of these grasses are seasonal and therefore do not permit maximum pasture utilization. Gains on Sudangrass pasture have not been satisfactory for finishing steers at the Rice Experiment Station. It is desirable to utilize forage to the maximum extent in fattening rations since southwest Louisiana is a feed-grain deficient area. It appeared desirable to compare ryegrass and Sudangrass pellets as 40, 60, and 80% of the ration, to a 40% rice straw ration and to ryegrass grazing.

REVIEW OF LITERATURE

Pelleting is an accepted method of increasing animal performance on high roughage rations. Oklahoma workers fed unpelleted rations containing 65, 50, 35, and 20% roughage to Hereford calves and reported average daily gains of 1.72, 1.71, 1.53, and 1.61 pounds (Pope *et al.*, 1957) and 2.18, 2.19, 2.12, and 2.12 pounds (McCroskey *et al.*, 1958). The roughage in each ration consisted of equal parts of chopped alfalfa hay and cottonseed hulls. The estimated slaughter grade was High Good to Low Choice. McCroskey *et al.* (1961) in two trials fed steers pelleted and unpelleted rations that had 1:4 and 4:1 concentrate:roughage ratios. The roughage consisted of equal parts of cottonseed hulls and chopped alfalfa hay. Steers gained 2.28 pounds per head per day when receiving the 1:4 pelleted ration, as compared with 1.86 pounds when they received the 1:4 unpelleted rations. Average daily gains by steers fed the 1:4 pelleted ration were comparable to gains by steers fed the 4:1 ration in the first trial and were only .17 pound less in the second trial. Carcass grades of cattle on the 4:1 ration were higher than those on the 1:4 ration. Carcass grades were similar (Good) for cattle fed pelleted or unpelleted 1:4 rations. McCroskey *et al.* (1960), in a station report, suggested that the response to pelleting was due to increased feed efficiency. Average daily gains of 1.89, 2.14, 2.14, and 1.96 with feed conversions of 12.13, 11.22, 11.07, and 10.63 pounds were observed when the 1:4 concentrate: roughage ration was fed as meal, reground pellets, pellets, and limited pellets, respectively. Comparison of the meal and reground pellet data suggests that changes occurred during the pelleting process.

Weir *et al.* (1959) reported average daily gains of 2.22, 2.29, and 2.14 pounds when steers received 100, 70, and 40% pelleted alfalfa hay rations, respectively. USDA carcass grades were Choice or above, except for the 40% group, in which there were two Good carcasses. Average daily gain and carcass grade followed the reverse order when these rations were fed in meal form. Intake increased and efficiency decreased as the level of alfalfa hay increased in the ration. Similar studies with lambs were equally satisfactory.

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Wallace and Hubbert (1959) reported average daily gains of 0.31 and 1.61 pounds when 365-pound calves were fed chopped or pelleted meadow hay, respectively, as the sole ration. Wallace *et al.* (1961) fed chopped, 4-inch wafered, and pelleted meadow hay to 355-pound steers and reported daily gains of 0.37, 0.30, and 0.71 pounds on 9.9, 10.1, and 12.3 pounds of hay. Nutrient digestibility was not significantly influenced by physical form, although there was a depressive trend in dry matter, cellulose, and energy digestibilities as a result of pelleting.

Meyer *et al.* (1959) presented results which indicated that increased gains by lambs fed pelleted as compared to chopped alfalfa hay were due to increased intake of the former. A faster passage from the reticulorumen seemed to be responsible for this increased feed intake. Total digestible nutrients, metabolizable energy, and net energy content were not significantly different for the two forms.

Hogan *et al.* (1966) found good-quality Coastal Bermudagrass pellets to be equal to alfalfa meal pellets in feeding value. Brooks and associates (1962) reported similar gains and efficiency when steers were fed Coastal Bermudagrass pellets or grain mixture. The steers dressed and graded lower when fed pellets. Beardsley *et al.* (1959) reported average daily gains and feed efficiencies of 2.60, 8.5; 2.68, 9.1; and 2.80 and 9.3 pounds when 70:30, 55:45, and 40:60 concentrate:roughage rations, respectively, were fed in the pelleted form to steers. The rations consisted of ground ear corn, cottonseed meal, blackstrap molasses, and Coastal Bermudagrass hay. Lindahl and Reynolds (1959) demonstrated that pelleting or regrinding pellets did not influence the chemical composition or digestibility other than the ether extract fraction, which was increased. McCormick and co-workers (1965), in an extensive feed value study of Coastal Bermudagrass pellets, demonstrated that gains, feed efficiency, dressing percent, and carcass grade could be increased by feeding 40 to 60% concentrate with the pellets.

PROCEDURE

The chemical composition of dehydrated ryegrass pellets, Sudangrass pellets, and rice straw used in this study is shown in Table 1. The pellets were purchased from a Louisiana dehydrator, and the only available information indicated that the ryegrass was cut in the late boot stage. Ration ingredients and chemical composition are presented in Table 2. The concentrate fed as meal was hand-mixed with the pellets in quantities that would be consumed in one or two days. The ryegrass pellets were softer than the Sudangrass pellets and would disintegrate in the feed trough. The rice straw ration, prepared in one process, was fed free-choice as meal. Dehydrated ryegrass pellets were not included

TABLE 1.—Chemical Composition of Forages

Item	Ryegrass pellets	Sudangrass pellets	Rice straw
	Percent		
Dry matter	89.0	93.7	88.7
Crude protein	13.1	8.1	3.7
Crude fiber	27.3	33.0	31.5
Nitrogen-free extract	36.7	44.3	35.3
Ether extract	4.6	3.1	2.1
Calcium	0.27	0.29	0.22
Phosphorus	0.32	0.21	0.11
Ash	7.3	5.2	16.1

in Trial 2 because they were not available. The same lot of dehydrated Sudangrass pellets was used in both trials.

The ryegrass pasture was sown in early fall on a prepared seedbed, with 60-60-30 pounds of N, P_2O_5, and K_2O applied per acre. During the grazing season 60 pounds of N were applied.

Yearling steers that had previously grazed on Sudangrass pasture during the summer were used in both Trials 1 and 2. In Trial 1, 64 Hereford steers were assigned to 16 groups of four steers. Two groups were randomly assigned to each treatment and fed as separate groups except those on ryegrass pasture, in which both groups grazed together. Fifty Hereford-Brahman steers were assigned to 10 groups of five steers in Trial 2. They were allotted and fed as in Trial 1 except without the dehydrated ryegrass pellet treatments. The steers were slaughtered after 140 days and carcasses graded according to USDA standards.

Rumen samples were taken via stomach tube from four steers on each ration near the end of Trial 1. The samples were processed and analyzed for volatile fatty acids by gas chromatography according to the procedure of Erwin *et al.* (1951).

Trial 3 was a digestibility study in which the 80, 60, and 40% dehydrated Sudangrass pellet rations used in Trials 1 and 2 and 100% dehydrated Sudangrass pellets were compared. Five Hereford steers were fed to a maximum consumption on each of these rations during a 21-day preliminary period followed by a 5-day fecal collection period. A 1% aliquot of feces was obtained daily and composited at the end of the trial. Feces were dried at 50° C. prior to analyzing. Analysis of feed and feces was according to A.O.A.C. (1955) methods.

RESULTS AND DISCUSSION

Trials 1 and 2

The feedlot performance data from Trial 1 are presented in Table 3. Average daily gains and carcass grade were significantly ($P<.01$) lower for the ryegrass grazed steers than for the fed steers. Steers grazing ryegrass dressed lower ($P<.01$) and had lighter weight carcasses ($P<.05$) than others except the 80% Sudangrass pellet fed steers. Carcass grade

TABLE 2.—Composition of Rations

	Dehydrated ryegrass pellets			Dehydrated Sudangrass pellets			Rice straw
Ration	80%	60%	40%	80%	60%	40%	40%
	Percent						
Ingredients:							
Forage	80.0	60.0	40.0	80.0	60.0	40.0	40.0
Ground grain sorghum	14.9	32.9	50.9	4.9	25.4	45.9	38.3
Soybean meal (50%)	—	2.0	4.0	10.0	9.5	9.0	16.6
Molasses	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Salt (trace mineral)	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Defluorinated phosphate	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin A—oxytetracycline	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Chemical analysis:							
Dry matter	89.2	89.5	89.7	91.0	90.7	90.0	90.3
Crude protein	12.3	12.5	12.4	12.1	12.3	11.9	12.5
Crude fiber	22.2	17.2	12.2	25.9	19.9	14.0	13.8
Nitrogen-free extract	43.0	49.5	56.0	43.9	50.0	56.1	52.4
Ether extract	4.2	3.8	3.7	3.1	3.0	3.1	1.9
Ash	7.5	6.5	5.4	6.2	5.5	4.9	9.7

TABLE 3.—Performance of Steers Fed Dehydrated Forage Pellets or Rice Straw in Complete Rations, and Steers Grazing Ryegrass in Trial 1

Item	Dehydrated ryegrass pellets			Dehydrated Sudangrass pellets			Rice straw	Rye-grass pasture
Level in ration, %	80	60	40	80	60	40	40	100
No. steers	8	8	8	8	8	8	8	8
No. days	140	140	140	140	140	140	140	140
Initial wt., lbs.	452	451	451	451	451	451	452	451
Daily feed, lbs.								
Forage	14.7	11.3	6.9	15.3	11.7	7.7	8.0	------
Concentrate	3.7	7.5	10.1	3.8	7.8	11.5	12.1	------
Daily gain, lbs.	2.00	2.23	2.19	2.12	2.32	2.29	2.02	1.54
Dressing, %	52.2	53.9	56.4	51.1	54.3	54.7	54.5	51.4
Carcass grade[1]	9.4	10.4	10.4	9.2	10.8	10.0	10.0	7.4
Hot carcass wt., lbs.	393	420	428	383	430	431	408	350

[1] Grades: 7 = Standard, 8 = High Standard, 9 = Low Good, 10 = Good, 11 = High Good.

was lower ($P<.05$) when steers were grazed than when fed. There was no significant difference in average daily gain of fed steers. Steers fed 40% ryegrass pellets dressed higher ($P<.05$) than those on other treatments. Steers that were fed 80% ryegrass or Sudangrass pellets dressed lower ($P<.05$) than those fed other rations. The carcasses were heavier ($P<.05$) when steers were fed pellets at the 40% level than at the 80% level. Carcasses were also heavier at the 60% level ($P<.05$) than for the 80% ryegrass pellets. The carcass grade was lower ($P<.05$) when steers were fed 80% Sudangrass pellets than when fed 40 or 60% ryegrass or 60% Sudangrass pellets. The 60% Sudangrass pellet fed steers graded higher ($P<.05$) than 80% ryegrass pellet fed steers.

The feedlot performance data from Trial 2 are presented in Table 4. Average daily gains, carcass weight, and carcass grade were higher ($P<.05$) for fed steers than for grazed steers. Steers fed 60% Sudangrass pellets dressed lower ($P<.05$) than those fed 40% rice straw or 40% Sudangrass pellet rations.

TABLE 4.—Performance of Steers Fed Dehydrated Sudangrass Pellets or Rice Straw in Complete Rations, and Steers Grazing Ryegrass in Trial 2

Item	Dehydrated Sudangrass pellets			Rice straw	Ryegrass pasture
Level in ration, %	80	60	40	40	100
No. steers	10	10	10	10	10
No. days	140	140	140	140	140
Initial wt., lbs.	524	523	523	523	523
Daily feed, lbs.					
Forage	17.0	11.9	8.6	9.0	---
Concentrate	4.3	7.9	12.8	13.5	---
Daily gain, lbs.	2.15	2.26	2.35	2.28	1.63
Dressing, %	58.0	57.2	59.1	59.0	58.0
Carcass wt., lbs.	478	505	504	498	413
Carcass grade[1]	9.8	10.2	10.3	10.3	8.8

[1] Grades: 7 = Standard, 8 = High Standard, 9 = Low Good, 10 = Good, 11 = High Good.

The results from Trials 1 and 2 for Sudangrass pellets, rice straw, and grazed ryegrass were combined. Steers grazing ryegrass gained less, graded lower, and had lighter carcasses ($P<.05$) than those on feed. Gains were not significantly different among the fed treatments, although there was a trend for gains to be higher with 40 and 60% Sudangrass pellets than with 80% Sudangrass pellets or 40% rice straw ration. A comparison of carcass weights showed that the 40 and 60% pellet rations were superior to the 80% pellet ration ($P<.05$). Carcasses from 40% rice straw fed steers were intermediate in weight. The carcass grade of 60% Sudangrass pellet fed steers was higher than that of 80% Sudangrass pellet fed steers ($P<.05$). Dressing percent was higher at the 40% forage level than with any other treatment ($P<.05$). This probably reflected more fill in steers receiving more roughage.

The combined feed efficiency data of both trials are presented in

Table 5 for dehydrated Sudangrass pellets and rice straw. The forage level did not significantly influence dry matter intake or efficiency in either trial or combined trials. While there was a trend toward higher average daily gain and feed efficiency at the 40 and 60% pellet level the differences were not significant, suggesting that the pellets have a high energy value. It should also be noted that the concentrate and Sudangrass pellets required per pound of gain were exactly reversed at the 40% (4.7 and 3.1 pounds, respectively) and 60% (3.1 and 4.7 pounds, respectively) levels. This further suggests that the dehydrated Sudangrass pellets and concentrate are similar in energy value. Average daily gain and carcass weight were similar at these pellet levels. Steers fed these pellets at 40 and 60% of the ration made gains similar to those reported by McCormick *et al.* (1965) for 30 and 60% but lower than found by Brooks and associates (1962) for 50% Coastal Bermudagrass pellets. McCormick *et al.* (1965) reported lower gains with 90 or 100% while Brooks *et al.* (1962) reported higher gain with 100% Coastal Bermudagrass pellets than reported herein for 80% pellets.

TABLE 5.—Average Efficiency of Steers Fed Dehydrated Sudangrass Pellets and Rice Straw (Trials 1 and 2)

	Dehydrated Sudangrass pellets			Rice straw
Item	80%	60%	40%	40%
Daily gain, lbs.	2.14	2.29	2.33	2.16
Daily dry intake, lbs.				
Forage	14.7	10.7	7.3	7.9
Concentrate	3.7	7.1	10.9	11.8
Dry feed per lb. gain, lbs.				
Forage	6.9	4.7	3.1	3.7
Concentrate	1.7	3.1	4.7	5.5
Carcass wt., lbs.	436	463	471	458

Rumen fluid was taken near the end of Trial 1 via stomach tube. The molar percent volatile fatty acids of the rumen fluid is shown in Table 6. Acetate production was not significantly influenced by the ration. Less ($P<.05$) propionate was produced when 40% Sudangrass pellets were fed than with other rations except 60% Sudangrass pellets. More ($P<.01$) isobutyrate was produced when steers were fed 40% Sudangrass pellets than when rations except 40% rice straw and 80% Sudangrass pellets were fed. More ($P<.05$) isobutyrate was produced when the two latter rations were fed than when 60 or 80% ryegrass pellets were fed. Butyrate concentration was greater with 40% Sudangrass pellets than with 40% ryegrass pellets ($P<.05$) and other rations ($P<.01$). Butyrate was lower with 80% Sudangrass pellets than with 80% ryegrass pellets ($P<.05$), 40 or 60% ryegrass or 60% Sudangrass pellets ($P<.01$).

TABLE 6.—Molar Percent Volatile Fatty Acids in Rumen Fluid Taken via Stomach Tube

	Dehy. ryegrass pellets			Dehy. Sudangrass pellets			Rice straw
Item	80%	60%	40%	80%	60%	40%	40%
Acetate	67.9	67.3	63.8	69.7	67.7	63.9	63.6
Propionate	15.5	15.5	15.2	14.6	14.1	11.9	17.1
Isobutyrate	0.53	0.57	0.71	0.96	0.76	1.25	0.96
Butyrate	15.0	15.9	17.2	12.0	16.0	20.0	14.5

Trial 3

Digestion coefficients for rations containing four levels of dehydrated Sudangrass pellets are presented in Table 7. Dry matter digestibility and total digestible nutrients (TDN) were significantly higher at the 40% pellet level than at the 100 ($P<.01$) or 80% ($P<.05$) levels. Dry matter digestibility was higher ($P<.05$) at the 60% than at the 100% level. The similarity in TDN of the 60 and 40% Sudangrass pellet rations further demonstrates the energy value of these pellets.

Crude protein digestibility was lower ($P<.01$) at the 100% level than at any other and was lower at the 40% level ($P<.05$) than at the 80% level. The concentrate portion of the 80% pellet ration contained a higher proportion of soybean meal, which may account for the higher crude protein digestibility of the latter ration. Although crude fiber digestibility followed the expected pattern by increasing with each increase in crude fiber, the only significance ($P<.01$) was between the 40% and higher levels. Nitrogen-free extract was more digestible at the 40% level than at the 100, 80 ($P<.01$), or 60% levels ($P<.05$). Nitrogen-free extract digestibility was higher at the 60% level than at the 100 ($P<.01$) or 80% ($P<.05$) levels. Ether extract digestibility was not influenced by pellet level.

TABLE 7.—Digestion Coefficients of Rations Containing Four Levels of Dehydrated Sudangrass Pellets

	Dehydrated Sudangrass pellets			
Item	100%	80%	60%	40%
Dry matter	59.4	61.2	63.6	65.7
Crude protein	52.5	63.0	60.2	58.1
Ether extract	81.2	79.4	79.5	79.8
Crude fiber	59.4	57.7	52.7	42.2
Nitrogen-free extract	59.9	62.3	68.8	73.9
Total digestible nutrients	61.0	61.6	64.0	66.8

SUMMARY

Average daily gains and carcass grades were higher when steers were fed rations containing 80, 60, and 40% dehydrated ryegrass or Sudangrass pellets or 40% rice straw than when steers grazed ryegrass. Average daily gains by the fed steers were not significantly influenced by the rations; however, carcass weight was higher at the 40 and 60% than at the 80% Sudangrass pellet level. The level of Sudangrass pellets did not significantly influence intake or efficiency. Concentrate and Sudangrass pellets per pound of gain were exactly reversed at the 40% (4.7 and 3.1 pounds, respectively) and 60% (3.1 and 4.7 pounds, respectively) levels. Gains and carcass weights were similar at these pellet levels. The similarity in TDN of the 60 and 40% Sudangrass pellet rations also demonstrates the energy value of these pellets. Volatile fatty acid data are presented.

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Boron Investigations with Cotton in Louisiana

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Boron Investigations with Cotton In Louisiana

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Introduction

In recent years the attention of many investigators has been focused upon the importance of boron in crop production. There is conclusive evidence that some soils in the United States are deficient in boron and will not produce a profitable crop yield under any system of soil management unless this essential micronutrient element is supplied *(29)*.[2]

Boron deficiencies are more widespread than deficiencies of any other micronutrient element. Specific recommendations for the prevention and correction of boron deficiency in one or more crops are made in 39 of the 50 states *(32)*. It has been estimated that as many as 15 million acres of cropland in the United States may have an inadequate supply of available boron in the soil and that crop yields and quality could be improved by proper periodic applications of boron *(36)*.

Boron deficiency symptoms are manifested in less spectacular ways than are deficiencies of macro and secondary nutrient elements and with less predictable consistency than other micronutrient element deficiencies. Boron deficiency in crops is often unrecognized; consequently, it has been referred to as "hidden hunger."

The severity of boron deficiency symptoms is often associated with liming of the soil and certain fertilizer practices (*30*). It has also been observed that the external symptoms of boron deficiency and of calcium deficiency are strikingly similar. This has led to the suggestion that the functions of boron and calcium in the plant are intimately associated in their general metabolic activities. There is some evidence (*30*) that potassium and boron are also closely related in their effects upon plant development, although this is not indicated by any similarity between the external symptoms induced by deficiencies of the two elements. Little is known, however, about the influence of the major essential cations, potassium, calcium, and magnesium, upon the response of the plant to boron when these elements are present in the nutrient substrate, or in the plant, either in deficient quantities or in concentrations in excess of those required for growth and development under optimum conditions.

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[2] Italic numbers in parentheses refer to Literature Cited, page 26.

Soybeans and clover grown on certain soils of the Coastal Plains in Louisiana have shown yield responses to applications of boron under greenhouse conditions. In all cases, the yield responses attributed to boron fertilization were obtained on coarse-textured soils that had received applications of fertilizer and lime. In certain instances, increased yields attributed to boron fertilization have been rather large, but these responses were noted on legume crops grown on soils in pots in the greenhouse. Laboratory and greenhouse studies cannot be expected to indicate very accurately what would occur in the field under actual farming conditions.

The primary objectives of this investigation were: (1) to determine the effect of boron fertilization on yield of cotton grown on soils under field conditions at different locations within the state, (2) to determine the level of boron in the soil and in the cotton leaves at each location, and (3) to relate cation exchange capacity, per cent base saturation, per cent organic matter, and dilute-acid-extractable calcium, magnesium, potassium, and phosphorus to hot-water-extractable boron and the yield of cotton.

Review of Literature

The literature on the subject of deficiency or sufficiency of boron as related to crop production is voluminous. No attempt has been made here to assemble an exhaustive bibliography of boron in agriculture. Attention has been focused more on research dealing with crops grown under field conditions. The earlier papers describing water and nutrient culture experiments are treated in less detail.

The earliest record of boron as a constitutent of plants appears to be that of Wittstein and Apoiger (*42*), who in 1857 obtained boric acid from the ash of seeds of *Maesa picta,* an Abyssinian plant belonging to the order *Myrsinaceae*. Later investigators have shown that boron occurs in the ash of all higher plants in small quantities, usually below 0.5 per cent. Brown algae, on the other hand, contain a greater quantity of the element, about 1.0 per cent of the ash (*12*). In the last quarter of the nineteenth century a considerable amount of work was done on the toxicity of boron to plants, and an excellent compendium of this subject was reported by Brenchley (*6*).

In 1910, Agulhon (*1*) published results of experiments showing increase in dry weight of wheat, oats, and radish grown in sand cultures when 0.5 milligram of boron was added to a kilogram of sand. He concluded that "boron is a useful element for higher plants" and included it with manganese among the elements which he regarded as forming a group of "catalytic fertilizers." Agulhon, however, failed to prove that normal growth is impossible in the absence of boron, nor did he describe symptoms by which boron deficiency might be recognized. The first of these requirements was furnished by Mazé (*22*) in 1915 in work with maize, but it was left for Warington in 1923 (*39*) to show conclusively not only that boron is a growth stimulant, but that in its absence, members of the order *Leguminosae* develop constant and easily recognizable symptoms of malnutrition. Such symptoms could be prevented in a culture solution containing one part of boric acid in 12,500,000 parts of water. Unfortunately, the nutrition of leguminous plants is somewhat abnormal owing to the presence on their roots of nodules containing bacteria which are capable of utilizing atmospheric nitrogen and rendering it available to their host plant. As a result, there was a tendency to regard the boron requirement of the *Leguminosae* as another indication of their specialized mode of nutrition, possibly connected with the maintenance of the normal balance between host and nodule bacteria. This view received some support from the fact that Warington failed to obtain satisfactory evidence of the necessity of boron for cereals and carried out few and inconclusive field tests. In 1926, however, Sommer and Lipman (*35*) published a series of photographs indicating greatly increased growth of sunflower, cotton, barley, buckwheat, castor bean, flax, and mustard seedlings when supplied with a trace of boron in water cultures. In 1928, Johnston (*15*) and Johnston and Dore (*16*) indicated the essential nature of boron for normal growth of potato and tomato, and in the following year, McMurtrey (*23*) provided similar evidence in the case of tobacco.

The attention of agriculturists was first focused on the problem by research conducted by Brandenburg in 1931 (*5*), which, for the first time, demonstrated clearly that boron deficiency occurs in the field and is the underlying cause of heart- and dry-rot in sugar beets and mangolds. The appearance of Brandenburg's paper stimulated inquiry into the part played by boron in the nutrition of other crops. The almost forgotten work of Agulhon (*1*) was confirmed, and in a surprisingly short time, compounds of boron took their place in the list of accepted commercial fertilizers.

Early investigations in the United States with boron as related to cotton production were primarily concerned with incidences of boron toxicity rather than deficiency (*9, 10, 28, 31, 33*). Manure salts and low-grade run-of-the-mine potassium salts contained boron as impurities, and Blackwell and Collings (*3*) reported seedling injury and decreased cotton yields from the use of potassium material that contained 17.8 per cent borax. Schreinir *et al.* (*31*) reported that the toxic limit of borax applied to cotton was between eight and nine pounds per acre. Plummer and Wolf (*28*) reported that, in sandy soils, cotton failed to grow in pots containing the borax equivalent of over one pound of boron per acre, while in clay soils marked injury was present only when the amount of boron exceeded seven pounds per acre. In a field experiment on a silt loam soil, Skinner and Allison (*33*) found that borax mixed with broadcast fertilizers was not always injurious to cotton plants when applied at the rate of five pounds per acre. However, it was noted that 10 pounds of borax was slightly injurious and the 20-pound rate was distinctly injurious. The 20-pound-per-acre application reduced the weight of green plants 15 to 35 per cent. When the boron was banded, five pounds of borax was slightly harmful, 10 pounds was distinctly injurious, and 20 pounds caused severe injury. When the fertilizer was applied and allowed to stand until after a rain and before the seed were planted, the injury in each case was less severe.

Following the earlier experiments which identified the presence of boron in plants, and later experiments which proved its essentiality and toxic nature, a great volume of literature has appeared dealing with the supplies of boron in soils and irrigation waters and with diagnostic methods employed to evaluate the boron status. Kelly and Brown (*17*) studied the soils and irrigation waters of southern California. Eaton (*10*) published a very comprehensive report on boron in soils and irrigation waters. He reported that boron has been found to be present in each of some 4,000 surface and underground waters in the western portion of the United States. In some of these waters its concentration has been sufficiently high to inhibit the growth of irrigated plants and in others so low that its presence was demonstrated only by special methods. An extensive survey was made by Whetstone *et al.* (*41*). They pointed out that there were four large areas in the United States where boron deficiency was likely to occur. These were: the Atlantic coastal plain, the Pacific coastal area, the Pacific Northwest, and northern Michigan, Wisconsin, and Minnesota.

Factors Affecting the Availability of Boron

There are many factors that affect the mobilization and subsequent solubility and availability of boron in soils. Emphasis, in this review, will be placed only on the most important factors frequently reported to be responsible for altering the availability of soil boron for use by plants. A thorough review of this important subject has been compiled by Hodgson (*14*).

According to Hodgson (*14*) and Page and Bergeraux (*27*), the most prominent factors that affect the mobilization of boron are: (1) organic matter, (2) soil reaction, (3) climate, (4) leaching and soil texture, and (5) crop removal.

1. **Organic Matter** – In the southern region of the United States the quantity of available boron in surface soil ranges from 0.02 to 2.5 parts per million, and apparently most of it is held in the organic fraction (*27*). In acid soils, available boron increases directly with the organic matter content. Available soil boron and the absorption of boron by plants has been reported to be more closely correlated with soil organic matter than with either soil texture or pH (*18*).

2. **Soil Reaction** – Soil reaction (pH) is one of the most important factors influencing boron availability. Several investigators (*24, 26, 43*) have reported that liming acid soils decreases the solubility of boron and causes boron deficiency. This decrease in the availability of boron was

formerly thought to be due to the stimulation of microbial activity in soils, thus causing a temporary fixation of boron in the cells of microorganisms. However, recently Hatcher *et al.* (*13*) postulated that lime-induced boron deficiency in plants is caused by decreases in the boron concentration of the soil solution resulting from additional adsorption by the $Al(OH)_3$ that precipitates when a soil is limed. These workers also reported that the amount of surface area over which the hydroxy-aluminum is spread is an important factor in boron adsorption.

3. **Climate** — Variations in boron uptake by plants are often more striking from year to year or within a season than from season to season (*14*). Outbreaks of boron deficiency are commonly associated with dry soil conditions and often the deficiency symptoms tend to disappear as soon as the surface soil layers are moistened (*27*). The lack of sufficient boron in dry periods may be due to a reduction in the release of boron from surface and subsurface soil layers.

4. **Leaching and Soil Texture** — In the southern region of the United States, loss of boron by leaching on certain soils may be one of the major factors contributing to boron deficiency (*14, 27*). Many of the soils are acid, low in organic matter, and subjected to leaching rains. The amount of boron leached is largely determined by soil texture (*19, 27*). Boron is more readily leached from sandy soils than from the finer-textured clay or silt soils (*19*). It should be pointed out, however, that sandy soils release boron more rapidly to plants, and consequently require less soluble boron than do finer-textured soils to support and maintain normal plant growth.

5. **Crop Removal** — Boron availability is also influenced by crop removal. Even though the quantity removed under most cropping conditions may not be large, boron deficiency is more likely to occur in highly-fertilized, fast-growing crops in which most of the above-ground portion is harvested.

Functions of Boron in Plants

More research has been reported on the relationship of boron to the reproductive processes of plants and the germination of pollen than on any other proposed function of the element (*27*). Boron accumulates in the pistil, and poor germination is common when the boron content is low. Boron has been found to be essential for normal germination of pollen grains and growth of pollen tubes. Frequently, increased yields resulting from applications of boron are associated with an increased set of both flowers and fruit.

Boron is considered essential for normal cell division. It has been suggested that boron plays a role in protein formation since, with a deficiency, both carbohydrates and nitrogen compounds accumulate while the young growing tips die (*37*).

Gauch and Dugger (*11*) proposed a theory that would tie together many different functions now assigned to boron. They suggested that boron in the cell membranes forms a temporary compound with carbohydrates which allows the carbohydrates to move rapidly through the plant. Thus, boron deficiency symptoms are considered to be expressions of carbohydrate deficiency. In support of this theory, boron deficiency occurs in the growing tip, conductive tissue, and roots, all of which are regions of rapid growth.

Boron is also associated with water relations within plants and in the production and translocation of plant hormones (*14*).

Symptoms of Boron Deficiency and Toxicity in Cotton Plants

Cotton plants require a small but continuous supply of soluble boron for normal growth and reproduction. Since boron is not mobile once it has been absorbed by the plant, it is not translocated from old to new tissue. Thus, visual symptoms of boron deficiency are usually associated with either new growth, conductive tissue, or fruiting forms.

Cotton plants may only exhibit visual deficiency symptoms in the reproductive organs. In such cases, flowers may vary from only a slight malformation to not being formed at all, or they may shed prematurely (*9, 19, 25, 27*). Seed may not set due to infertility of the ovary or failure of the pollen to germinate. Frequently the developing fruit drops early.

Page and Bergeraux (*27*) stated that under field conditions visual symptoms of boron deficiency seldom develop on the foliage. These workers reported that the first symptoms of boron deficiency in the cotton plants was an excessive shedding of flower buds and young bolls. Shedding due to boron deficiency can be distinguished from boll weevil damage by examination. Shedding due to boron deficiency was most prevalent during dry years.

In more severe cases of boron deficiency, the internodes are shorter, and the terminal bud may die, producing a short bushy plant with excessive branching. The younger leaves are yellowish-green in color and are often distorted if the deficiency is severe (*9*).

Another visual symptom which is associated with a deficiency of boron is "banded petioles" (*25*). Leaf petioles of cotton plants growing on soils containing inadequate amounts of soluble boron develop concentric dark-colored rings, and this malady has been observed when the plants are blooming. Nitrogen, and to a lesser degree potassium, fertilization has been reported to be associated with this condition since more banding frequently occurs on petioles of cotton plants receiving higher amounts of these two macronutrient elements.

The injury produced by excessive amounts of soluble boron, as contrasted with the injury produced by other substances, is distinctive in its effect upon plant foliage. The typical symptoms associated with excessive and toxic amounts of boron are striking, and in many cases they are clearly distinguishable from those normal to maturation. Since there is a tendency for cotton plants to concentrate boron in their leaves, these organs are typically the first to exhibit its injurious effects. When boron is present in the soil in excessive amounts, the apical margins of the leaves of cotton plants first turn yellow; the yellowing then extends between the lateral veins toward the midveins. The chlorophyll in the tissue at the center and base of the leaves and adjacent to the veins is usually retained until the leaves have dropped from the plant. Areas of dead tissue develop as yellowing progresses. These dead areas may coalesce near the periphery of the leaf (*10*).

Maples (*21*) reported that the symptoms of boron toxicity in cotton were delayed emergence and growth, chlorosis, marginal leaf burn, downward cupping of leaves, shedding of damaged leaves, and death of some plants.

Experimental Procedures

The research reported here was conducted during a five-year period, 1963-1967. Fifty-nine field experiments with boron on cotton were conducted at 49 locations in Louisiana. The experiments were located on soils in the major cotton-producing areas of the state. The soil type, location, cooperator, and year of the experiments are presented in Table 1. For the purpose of identification and convenience in reporting, each soil and location was arbitrarily assigned a number from 1 to 49.

The experimental design at each of the 49 locations was a paired comparison with two treatments: boron, and no boron. With the exception of the experiments conducted in 1963, ten replications of each boron treatment were used. In 1963, six replications of each of the two boron treatments were used. Each plot consisted of four rows which were 40 inches wide and 50 feet long. On the plots that received boron, all four rows were treated. In order to minimize the possibility of border effect, the two center rows of each plot were harvested for yield measurements.

Boron was applied at a rate of one pound per acre. Sodium tetraborate, $Na_2B_40_7 \bullet 0.4\ H_20$, containing 20.5 per cent boron served as the source of the element. The material was placed in two bands, one on each side of the row shortly after the cotton was up to a stand. The boron material was dissolved in water and applied in an aqueous solution by means of a gravity flow applicator. Care was taken to avoid applying the boron material on the cotton seedlings.

Prior to the initiation of the field experiments, surface and subsoil samples were collected from the 49 experimental locations. To eliminate contamination with boron and other plant nutrient elements, all soil samples were collected and stored in 18-ounce Nasco polyethylene bags.

Extractable phosphorus, potassium, calcium, magnesium, hot-water-soluble boron, and soil reaction (pH) were determined on all surface samples. The content of hot-water-soluble boron was determined at varying depths on certain soils. Phosphorus was determined by extracting the soil with 0.10 normal hydrochloric acid containing 0.03 normal ammonium fluoride at a soil to extracting solution ratio of 1:20. After a color developed upon the addition of a solution of sulphuric acid-ammonium molybdate and stannous chloride, the concentration of phosphorus was measured by means of a Bausch and Lomb spectrophotometer. The soil cations potassium, calcium, and magnesium were deter-

TABLE 1.—Soil types and locations of field experiments with boron on cotton conducted in Louisiana (1963-1967)

Experiment number	Soil type[1]	Location (parish)	Cooperator[2]	Year(s)
Coastal Plain Soils				
1	Iuka sl	Caldwell	W. G. Gates	1963
2	Iuka vfsl	Caldwell	E. Puckett	1963
3	Mantachie fsl	Catahoula	C. E. Myers, Jr.	1965
4	Iuka vfsl	Catahoula	T. E. Kirby	1964
5	Shubuta sl	Lincoln	Lamar Colvin	1965
6	Gilead sl	Lincoln	Lamar Colvin	1966
7	Ochlockonee sl	Ouachita	Travis Howard	1963
Mississippi Terrace Soils				
8	Patoutville sil	Acadia	W. B. Matte	63-64
9	Olivier sil	E. Baton Rouge	Perkins Rd. Exp. Sta.	1963
10	Loring vfsl	Franklin	Ray Bryan	1964
11	Loring sil	Franklin	M. E. McKee	1963
12	Olivier sil	Franklin	Macon Ridge Exp. Sta.	63-67
13	Calhoun sil	Morehouse	Tonzie McCowan	1963
14	Calhoun sil	Richland	A. L. Dunn	1963
15	Olivier sil	Richland	C. L. Morris	1964
16	Loring sil	St. Landry	Leo Rabalais	1964
17	Olivier sil	West Carroll	Edward Philley	1964
18	Olivier sil	West Carroll	Don Major	1963
Alluvial Soils of the Ouachita River and Distributaries of the Arkansas River				
19	Gallion vfsl	Caldwell	Aussie B. Grigg	1964
20	Gallion vfsl	Caldwell	Rowland Brothers	1964
21	Hebert sil	Caldwell	U. M. Youngblood	1964
22	Hebert sil	Caldwell	B. F. Bauman	1964
23	Perry lfs	Catahoula	J. D. Alexander, Jr.	1965
24	Hebert vfsl	Catahoula	A. L. Huff	1966
25	Hebert vfsl	Morehouse	Duke Barr	1964
26	Hebert vfsl	Morehouse	Melvin Bolin	1964
27	Pulaski vfsl	Morehouse	George Sawyer	1966
28	Gallion vfsl	Morehouse	W. H. Dillon	1963
29	Gallion vfsl	Ouachita	W. A. Calloway & Son	1964
30	Hebert vfsl	Richland	Hollis Venable	1964
Mississippi River Alluvial Soils				
31	Dundee sil	Catahoula	W. H. Beasley	1964
32	Dundee sil	Concordia	Sam H. Calvert	1966
33	Commerce sil	Madison	Bobby Joe Lee	1966
34	Commerce sil	Tensas	N. E. La. Exp. Sta.	66-67

(Continued)

TABLE 1 (Continued).—Soil types and locations of field experiments with boron on cotton conducted in Louisiana (1963-1967)

Experiment number	Soil type[1]	Location (parish)	Cooperator[2]	Year(s)
		Alluvial Soils of the Red River		
35	Yahola sil	Avoyelles	Burton Bordelon	1964
36	Yahola vfsl	Bossier	R. R. Valley Exp. Sta.	64-66
37	Norwood sil	Bossier	Rowe Viola	1964
38	Yahola vfsl	Caddo	Gordon Vanhoose, Jr.	1964
39	Yahola sil	Caddo	Dan Logan	1964
40	Gallion sl	Grant	Winn Gatlin	1964
41	Gallion sl	Grant	Ben Littlepage	1964
42	Yahola vfsl	Grant	W. M. Racine	1964
43	Yahola fsl	Natchitoches	Adrian Land	1964
44	Yahola vfsl	Natchitoches	Deloy Blewer	1964
45	Yahola vfsl	Rapides	L. A. Marien	1964
46	Norwood sil	Rapides	Dean Lee Ag. Center	64-66
47	Pulaski vfsl	Red River	T. C. Blount	1964
48	Miller vfsl	Red River	Larry Bundrick	1964
49	Yahola vfsl	Red River	Ed Lester	1964

[1] The soils were classified by S. A. Lytle, Associate Agronomist, Louisiana Agricultural Experiment Station.

[2] The cooperators were selected by Cooperative Extension Service personnel in each of the parishes.

mined by extracting the soil with 0.10 normal hydrochloric acid and a soil to solution ratio of 1:20. The contents of potassium and calcium in the soil were determined on the extract on a flame spectrophotometer. The concentration of magnesium in the extract was determined on the atomic absorption spectrophotometer. Hot-water-soluble boron in the soils was determined by the curcumin method as described by Dible, Truog, and Berger (*8*). Soil reaction (pH) was measured by using a pH-meter and a slurry of soil and distilled water at a ratio of approximately 1:1.

The cation exchange capacity, the exchangeable cations, and the organic matter content of the surface soils were also determined at each experimental location. A method reported by Chapman and Pratt (*7*) involving the use of ammonium acetate adjusted to pH 7.0 was used to measure the cation exchange capacity of the calcareous and non-calcareous soils. Ammonium acetate was also used to determine the exchangeable soil cations with the exception of calcium in the alluvial soils of the Red River. Since some of the Red River soils are calcareous, an alcoholic solution of potassium chloride was employed to determine the exchangeable calcium in these soils (*7*).

The organic matter content of the surface soils was determined by the chromic acid method developed by Walkley and Black (*38*). The chromic acid method based on spontaneous heating by dilution of sulphuric acid afforded the advantage of differentiating between soil humus and extraneous sources of organic carbon.

Cotton leaves from each plot at the 49 experimental locations were sampled when the plants were in the early bloom stage of growth. The first mature leaf from the top of the plant was selected for the chemical analysis. Ten leaves from cotton plants growing on each plot were taken at random. The leaves collected from the ten replications for each of the two boron treatments were composited. The cotton leaf tissue was placed in cloth bags and dried in a forced draft oven at 70C. After drying for 24 hours, the cotton leaves were ground in a Wiley mill to pass a 20-mesh sieve and stored in four-ounce wide-mouth specimen bottles. The concentration of boron in the leaves was determined by the curcumin method reported by Dible, Truog, and Berger (*8*).

Statistical Analysis

The methods used in the statistical analysis are described and illustrated by LeClerg, Leonard, and Clark (*20*) and Snedecor (*34*). "Students" method of paired comparison was employed to calculate the standard error of the mean difference and the "t" test for significance of the yield data to determine the response of cotton to boron fertilization. Simple correlation coefficients were calculated to relate certain chemical properties of the cotton plants with the soils used in the investigations.

TABLE 2.—Chemical properties of the surface soils

Experiment number	Soil type	Extractable[1]				Water soluble	Organic	
		P	K	Ca	Mg	B	matter	pH
		— — — — (parts per million)				— — — —	(per cent)	
		Coastal Plain Soils						
1	Iuka sl	43	90	363	129	0.16	0.84	5.2
2	Iuka vfsl	40	78	861	165	0.26	0.97	6.3
3	Mantachie fsl	105	83	700	170	0.16	0.86	5.5
4	Iuka vfsl	112	126	1270	165	0.18	0.59	6.6
5	Shubuta sl	76	85	340	65	0.16	0.84	6.2
6	Gilead sl	50	100	430	35	0.19	0.39	5.8
7	Ochlockonee sl	89	78	816	217	0.31	0.58	7.1
		Mississippi Terrace Soils						
8	Patoutville sil	42	69	816	143	0.20	0.67	6.6
9	Olivier sil	38	66	762	208	0.37	0.97	5.9
10	Loring vfsl	49	126	544	156	0.31	0.75	5.9
11	Loring sil	66	66	544	156	0.17	0.99	5.6
12	Olivier sil	48	104	397	140	0.17	1.16	5.4
13	Calhoun sil	43	114	1678	217	0.22	1.08	6.3
14	Calhoun sil	89	78	816	217	0.12	0.58	5.2
15	Olivier sil	52	102	771	208	0.28	0.70	6.4
16	Loring sil	72	102	907	103	0.34	0.88	6.4
17	Olivier sil	43	78	816	285	0.25	0.77	6.1
18	Olivier sil	57	102	861	199	0.14	0.89	5.7

(Continued)

TABLE 2 (Continued).—Chemical properties of the surface soils

Experiment number	Soil type	Extractable[1]				Water soluble	Organic matter	pH
		P	K	Ca	Mg	B		
		(parts per million)					(per cent)	
	Alluvial Soils of the Ouachita River and Distributaries of the Arkansas River							
19	Gallion vfsl	152	180	453	165	0.21	0.79	5.8
20	Gallion vfsl	123	210	499	133	0.28	0.66	5.6
21	Hebert sil	149	204	952	235	0.31	0.89	6.0
22	Hebert sil	69	108	1134	320	0.37	1.00	5.9
23	Perry lfs	134	135	600	186	0.12	1.28	5.4
24	Hebert vfsl	33	125	760	212	0.18	0.95	6.3
25	Hebert vfsl	72	100	800	118	0.15	0.67	6.5
26	Hebert vfsl	78	96	816	208	0.19	0.59	6.3
27	Pulaski vfsl	86	125	640	199	0.19	0.90	6.5
28	Gallion vfsl	80	210	771	97	0.25	1.16	5.9
29	Gallion vfsl	268	324	816	235	0.42	0.94	6.1
30	Hebert vfsl	180	150	725	251	0.28	0.68	6.1
	Mississippi River Alluvial Soils							
31	Dundee sil	139	66	1179	312	0.28	0.78	6.3
32	Dundee sil	141	176	2030	356	0.42	1.17	6.2
33	Commerce sil	191	125	1860	417	0.45	1.08	6.2
34	Commerce sil	220	140	1280	326	0.41	1.29	6.0
	Alluvial Soils of the Red River							
35	Yahola sil	221	150	3834	1280	0.45	1.22	7.3
36	Yahola vfsl	137	114	1043	364	0.30	0.56	7.1
37	Norwood sil	192	246	9066	1990	0.56	0.96	7.6
38	Yahola vfsl	149	114	8024	1280	0.49	0.69	7.8
39	Yahola sil	160	138	3854	1074	0.53	0.70	7.5
40	Gallion sl	134	150	544	118	0.23	0.55	5.7
41	Gallion sl	80	90	408	118	0.28	0.55	5.4
42	Yahola vfsl	103	84	1134	381	0.41	0.65	6.3
43	Yahola fsl	215	168	997	245	0.39	0.59	5.7
44	Yahola vfsl	157	120	3990	826	0.46	0.48	7.5
45	Yahola vfsl	149	78	1859	409	0.48	1.35	7.3
46	Norwood sil	172	96	8841	1500	0.60	0.85	7.6
47	Pulaski vfsl	143	114	680	156	0.33	0.74	5.1
48	Miller vfsl	156	138	4353	912	0.46	0.65	7.4
49	Yahola vfsl	149	126	1224	303	0.48	0.66	6.4

[1] Phosphorus was extracted with 0.1 normal hydrochloric acid containing 0.03 normal ammonium fluoride at a soil to extracting solution ratio of 1:20. Potassium, calcium, and magnesium were extracted with 0.1 normal hydrochloric acid at a soil to extracting solution ratio of 1:20.

Results and Discussion

Chemical properties of the surface soils used in the boron investigations are presented in Table 2. The phosphorus and potassium statuses of the soils were considered to be adequate for determining the effect of applied boron on the yield of cotton.

The boron content of the soils varied from 0.12 ppm on Perry loamy fine sand located in Catahoula Parish to 0.60 ppm on Norwood silt loam in Rapides Parish. The boron contents of the Coastal Plain soils and alluvial soils of the Ouachita River and distributaries of the Arkansas River were considerably lower than the boron contents of the Mississippi Terrace soils and the alluvial soils of the Mississippi and Red rivers. The alluvial soils of the Red River contained the highest contents of water-soluble boron. The organic matter content of most of the soils was found to be very low. The low organic matter content of some of the soils may have been due to continuous cropping for many years. The pH of the soils ranged from 5.2 to 7.5. Sixty per cent of the alluvial soils of the Red River were alkaline in reaction.

The exchangeable cations potassium, sodium, calcium, and magnesium, the cation exchange capacity, and the per cent base saturation of the surface soils used in the boron investigations are presented in Table 3. The cation exchange capacity of the soils varied from 3.98 me. per 100 grams for Gilead sandy loam in Lincoln Parish to 22.79 me. per 100 grams for Commerce silt loam in Madison Parish. The cation exchange capacities of the Coastal Plain soils were lower than those of the other soils included in the investigations. However, there was a considerable amount of variation within each of the five different soil areas. There was

TABLE 3.—Exchangeable cations, cation exchange capacity, and per cent base saturation of surface soils

Experiment number	Soil type	Exchangeable cations				Cation exchange capacity	Base saturation
		K	Na	Ca	Mg		
		— — — — — — — (me./100 gms)				— — — — — — —	(per cent)
		Coastal Plain Soils					
1	Iuka sl	0.21	0.16	1.90	.79	7.16	42.7
2	Iuka vfsl	0.18	0.22	4.21	1.08	8.76	65.0
3	Mantachie fsl	0.36	0.13	3.42	1.51	6.97	77.8
4	Iuka vfsl	0.27	0.16	3.95	.98	7.16	88.8
5	Shubuta sl	0.20	0.13	1.88	.45	4.98	53.4
6	Gilead sl	0.14	0.12	3.05	.16	3.98	87.2
7	Ochlockonee sl	0.18	0.11	2.87	.82	4.78	83.3
		Mississippi Terrace Soils					
8	Patoutville sil	0.22	0.18	3.69	1.14	7.71	67.7
9	Olivier sil	0.20	0.37	4.54	1.85	11.34	61.4
10	Loring vfsl	0.36	0.11	2.58	.80	7.96	48.4
11	Loring sil	0.43	0.19	3.28	1.20	9.55	53.4
12	Olivier sil	0.30	0.28	2.85	1.00	10.15	43.6
13	Calhoun sil	0.29	0.17	6.59	1.49	11.64	75.1
14	Calhoun sil	0.19	0.26	2.39	.91	12.34	30.4
15	Olivier sil	0.28	0.13	4.81	1.41	12.14	54.6
16	Loring sil	0.28	0.11	4.69	.58	9.95	56.9
17	Olivier sil	0.25	0.16	4.47	2.20	14.93	47.4
18	Olivier sil	0.27	0.25	3.66	1.25	11.14	48.7

(Continued)

TABLE 3 (Continued).—Exchangeable cations, cation exchange capacity, and per cent base saturation of surface soils

Experiment number	Soil type	Exchangeable cations				Cation exchange capacity	Base saturation
		K	Na	Ca	Mg		
		(me./100 gms)					(per cent)
Alluvial Soils of the Ouachita River and Distributaries of the Arkansas River							
19	Gallion vfsl	0.43	0.12	2.42	1.02	6.37	62.6
20	Gallion vfsl	0.48	0.12	2.59	.71	5.77	67.6
21	Hebert sil	0.48	0.16	4.23	1.05	7.96	74.4
22	Hebert sil	0.28	0.19	4.68	2.33	13.33	56.1
23	Perry lfs	0.28	0.11	2.98	1.10	7.96	56.2
24	Hebert vfsl	0.42	0.15	3.80	1.16	7.06	78.3
25	Hebert vfsl	0.22	0.11	2.88	.68	5.47	71.1
26	Hebert vfsl	0.21	0.23	3.45	.76	5.97	77.9
27	Pulaski vfsl	0.38	0.12	2.65	.99	6.57	63.2
28	Gallion vfsl	0.49	0.19	3.76	.49	10.75	45.9
29	Gallion vfsl	0.67	0.18	3.76	1.40	8.76	68.6
30	Hebert vfsl	0.37	0.28	3.20	1.13	7.26	68.6
Mississippi River Alluvial Soils							
31	Dundee sil	0.18	0.19	4.83	1.79	9.75	71.7
32	Dundee sil	0.58	0.13	11.55	2.58	20.90	71.0
33	Commerce sil	0.43	0.19	11.73	3.97	22.79	71.6
34	Commerce sil	0.37	0.13	7.85	2.66	14.13	77.9
Alluvial Soils of the Red River							
35	Yahola sil	0.46	0.12	11.45	3.71	20.10	78.3
36	Yahola vfsl	0.30	0.13	4.61	2.14	8.56	75.1
37	Norwood sil	0.49	0.16	6.37	1.28	9.65	86.0
38	Yahola vfsl	0.27	0.20	7.54	1.08	11.74	77.4
39	Yahola sil	0.31	0.13	5.85	1.38	9.75	78.7
40	Gallion sl	0.33	0.10	1.98	.74	5.37	58.7
41	Gallion sl	0.21	0.10	2.24	.78	5.57	59.8
42	Yahola vfsl	0.29	0.37	4.33	2.66	11.14	66.5
43	Yahola fsl	0.40	0.11	4.03	1.56	8.36	73.0
44	Yahola vfsl	0.28	0.16	5.13	1.37	7.16	96.9
45	Yahola vfsl	0.23	0.13	4.47	2.15	9.55	73.1
46	Norwood sil	0.33	0.16	6.59	3.05	12.42	81.5
47	Pulaski vfsl	0.34	0.10	3.46	1.07	8.96	55.5
48	Miller vfsl	0.30	0.10	5.55	1.10	8.56	82.4
49	Yahola vfsl	0.33	0.11	5.07	2.15	10.15	75.5

less variation in the cation exchange capacity of the Mississippi Terrace soils than in the other soils studied.

The per cent base saturation of the soils varied from 42.7 per cent for Iuka sandy loam in Caldwell Parish to 96.9 per cent for the Yahola very fine sandy loam in Natchitoches Parish. The alluvial soils of the Red and Mississippi rivers contained higher amounts of exchangeable cations and had a higher percentage of base saturation than did the soils comprising the other soil areas.

The effects of applied boron on the yield of cotton and the boron con-

TABLE 4.—The effect of applied boron on the yield of cotton and the boron content of cotton leaves

		Yield			Boron content of cotton leaves[1]		
		Pounds of seed cotton/acre			ppm		
Experiment number	Soil type	No boron	Boron	Increase or decrease	No boron	Boron	Per cent increase
Coastal Plain Soils							
1	Iuka sl	2200	2172	— 28			
2	Iuka vfsl	2240	2293	53			
3	Mantachie fsl	1562	1603	41	26.0	26.6	2.3
4	Iuka vfsl	2391	2261	—130	20.1	33.6	67.2
5	Shubuta sl	1415	1732	317	16.5	22.8	38.2
6	Gilead sl	1484	1641	157*			
7	Ochlockonee sl	1798	1791	— 7			
Mississippi Terrace Soils							
8	Patoutville sil	2248	2192	— 56	41.7	43.2	3.6
9	Olivier sil	1678	1607	— 71			
10	Loring vfsl	2009	1998	— 11	33.6	43.5	29.5
11	Loring sil	2849	2910	61	22.7	34.0	49.8
12	Olivier sil	1356	1324	— 32	21.5	29.5	37.2
13	Calhoun sil	1991	1829	—162			
14	Calhoun sil	1575	1627	52			
15	Olivier sil	1305	1299	— 6	17.8	26.0	46.1
16	Loring sil	2123	2048	— 75	35.3	51.4	45.6
17	Olivier sil	1106	1112	6	19.0	27.0	42.1
18	Olivier sil	1445	1430	— 15			
Alluvial Soils of the Ouachita River and Distributaries of the Arkansas River							
19	Gallion vfsl	2342	2327	— 15	30.8	49.8	61.7
20	Gallion vfsl	4650	4394	—256	36.0	47.5	31.9
21	Hebert sil	2855	2854	— 1	31.2	40.3	29.2
22	Hebert sil	2009	2079	70	36.4	45.0	23.6
23	Perry lfs	2553	2773	220	25.1	31.4	25.1
24	Hebert vfsl	2884	2896	12			
25	Hebert vfsl	2074	2112	38			
26	Hebert vfsl	174	900	726**	7.2	21.0	191.7
27	Pulaski vfsl	1534	1885	351**			
28	Gallion vfsl	2574	2792	218			
29	Gallion vfsl	2087	1976	—111	35.5	42.9	20.8
30	Hebert vfsl	3736	3920	184	29.6	41.4	39.9
Mississippi River Alluvial Soils							
31	Dundee sil	2384	2107	—277	26.4	31.7	20.1
32	Dundee sil	2350	2283	— 67			
33	Commerce sil	2674	2533	—141			
34	Commerce sil	2928	2890	— 38			

(Continued)

TABLE 4 (Continued).—The effect of applied boron on the yield of cotton and the boron content of cotton leaves

		Yield: Pounds of seed cotton/acre			Boron content of cotton leaves[1]		
				Increase	— — — — ppm — — — —		
Experiment number	Soil type	No boron	Boron	or decrease	No boron	Boron	Per cent increase
— — — — — — — —		Alluvial Soils of the Red River — — — — — — — —					
35	Yahola sil	2120	2010	—110	45.7	46.9	2.6
36	Yahola vfsl	1775	1827	52	57.2	68.2	19.2
37	Norwood sil	1062	1005	— 57	71.3	76.5	7.3
38	Yahola vfsl	2169	2256	87	57.5	61.7	7.1
39	Yahola sil	1505	1495	— 10	74.2	87.1	17.4
40	Gallion sl	1432	1470	38	75.2	93.4	24.2
41	Gallion sl	1058	1013	— 45	45.6	55.5	21.7
42	Yahola vfsl	2699	2659	— 40	71.9	80.5	12.0
43	Yahola fsl	1771	1686	— 85	64.6	73.8	14.2
44	Yahola vfsl	1938	1734	—204	40.6	46.6	14.8
45	Yahola vfsl	2053	1955	— 98	59.4	69.6	17.2
46	Norwood sil	2916	2693	—223			
47	Pulaski vfsl	757	768	+ 11	76.9	103.3	34.0
48	Miller vfsl	1504	1524	20	65.0	67.7	4.2
49	Yahola vfsl	1275	1303	28	111.4	117.5	5.5

*Differences in yield were significant at the 5% level of probability.
**Differences in yield were significant at the 1% level of probability.
[1] Top-mature leaves were selected at the early-bloom stage of growth.

tent of top-mature cotton leaves are presented in Table 4.

There was a significant yield response to boron at three of the 49 experiment locations. The application of one pound of boron per acre resulted in significant increases in the yield of cotton grown on Gilead sandy loam in Lincoln Parish, experiment number 6, and on Hebert very fine sandy loam, experiment number 26, and Pulaski very fine sandy loam, experiment number 27, in Morehouse Parish. The hot-water-soluble boron content of the Gilead, Hebert, and Pulaski surface soils was 0.19 ppm. This is in agreement with research conducted by Ouellette and LaChance and reported by Bradford (*4*) in which boron deficiency occurred mainly on light sandy soils averaging 0.34 pound of hot-water-soluble boron per acre. The largest increase in yield, 726 pounds of seed cotton per acre, resulting from the application of boron occurred on the Hebert soil in Morehouse Parish. The largest increase in the boron content of cotton leaves resulting from the application of boron also occurred on the Hebert soil.

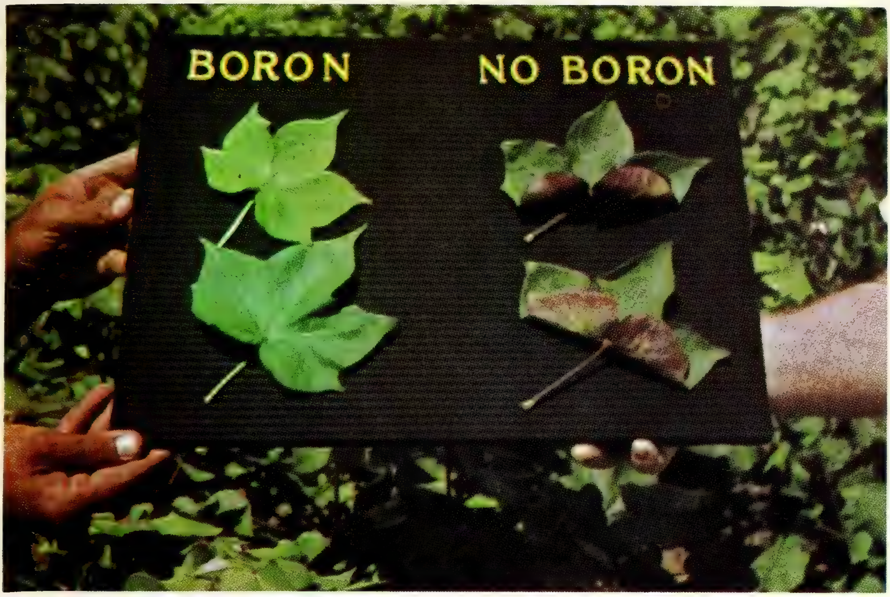
The largest increase in yield resulting from the application of boron on Coastal Plain soils occurred on Shubuta sandy loam, experiment number 5. This increase of 317 pounds of seed cotton per acre was not statistically significant, probably because of a wide variation in the stand of cotton on the plots. However, the beneficial effect of boron on plant growth was very apparent on July 22 when leaf samples were taken for chemical analysis. Top-mature leaves and petioles on the cotton plants that had received added boron were larger and had a darker green color than those on the check plots.

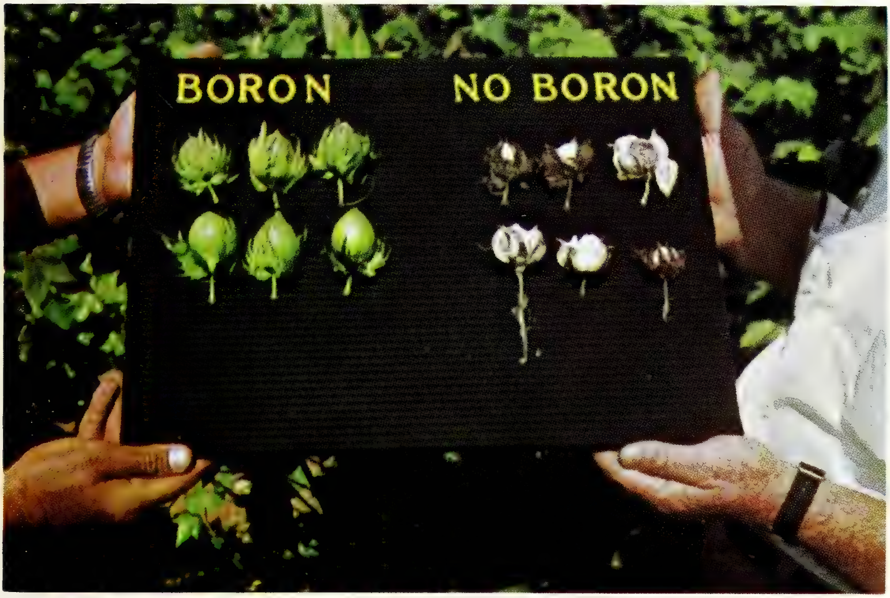
In experiment number 26, in Morehouse Parish, differences in plant growth resulting from the application of boron were apparent in each of the ten replications, from one month prior to harvest until the cotton was harvested on October 19. Leaves of plants growing on soil that did not receive boron appeared to be wilted. No harmful plant parasitic nematodes were present in the soil. Also, where boron was not applied, mature leaves at the top of the stalk developed a purple discoloration and there was a tendency for leaves to curl upward at their base. Small immature bolls that failed to open were characteristic of plants that had not received boron.

Lancaster *et al.* (*19*) reported that cotton plants growing on soils that did not receive boron produced bolls that were small and failed to open properly, and that many rotted before opening. Although leaves and bolls appeared to be normal on cotton plants grown on boron-treated soil in experiment number 26 in Morehouse Parish, a heavy boll set was not obtained, since an average of only 900 pounds of seed cotton per acre was produced, as compared with an average of 174 pounds on untreated plots. It was apparent during the growing season that inadequate available soil moisture was limiting the growth of the cotton plants. An examination of the soil and the root system of cotton plants growing on the Hebert soil indicated that a hard pan or plow sole at a depth of approximately six inches from the soil surface may have prevented the plants from obtaining water and plant nutrients necessary for normal growth. The limited supply of moisture was partially responsible for low yields of cotton, irrespective of boron treatment. Under moderate to severe stages of boron deficiency, various leaf abnormalities such as curling, wrinkling, and wilting of plants in general have been reported by Bradford (*4*). The cotton leaf-petiole abnormality termed "banded petioles," described and noted by Lancaster *et al.* (*19*) and Miley (*25*) and associated by these workers with inadequate amounts of soluble boron in the soil, was not observed in experiments conducted on the Hebert and Pulaski soils in Morehouse Parish or on Gilead soil in Lincoln Parish.

The boron content of the tissue of different parts of cotton plants growing on Hebert very fine sandy loam, as affected by boron fertilization is presented in Table 5. The application of boron increased the boron content of all plant parts. A relatively large increase in the boron content of top-mature leaves resulted from the application of boron. An increase of approximately 14 ppm, or 191.7 per cent, of boron in top-mature leaf tissue was attributed to the boron application.

The data suggest that plant tissue analyses used in conjunction with soil analyses can be employed as diagnostic criteria for determining boron deficiency. The critical concentration of boron in cotton leaves, below





TOP PICTURE: Leaf colorations attributed to boron deficiency. **BOTTOM PICTURE:** Immature cotton bolls that failed to open because of lack of boron.

which a response to boron would be expected, appeared to be about 15 ppm. Eaton, as reported by Bradford (*4*), demonstrated that cotton leaves containing 16.0 ppm of boron exhibited boron deficiency symptoms. The cotton plants were grown by Eaton in sand culture and the leaves were sampled in November.

The relationships between hot-water-extractable soil boron, the boron content of cotton leaves, and certain chemical properties of the soils are presented in Table 6.

TABLE 5.—Effect of applied boron on the content of boron in the tissue of different parts of cotton plants growing on Hebert very fine sandy loam, Morehouse Parish, 1964

Part of plant[1]	No boron	Boron[2]	Increase
	ppm	ppm	%
Top-mature leaves	7.2	21.0	191.7
Top-mature petioles	10.2	21.7	112.7
All leaves	8.4	16.2	92.9
All petioles	7.4	19.2	159.5
Secondary stems	9.4	14.1	50.0
Main stems	5.9	9.0	52.5
Roots	7.3	11.0	50.7
Fruiting forms[3]	4.4	6.7	52.3

[1] All samples collected on September 19, one month prior to harvest.

[2] Boron was applied at the rate of one pound per acre, as sodium tetraborate, 20.5% B.

[3] Fruiting forms did not include seed or lint.

TABLE 6.—The relationship between hot-water-extractable soil boron, the boron content of cotton leaves, and certain chemical properties of the soils

	Soil boron (X)		
Plant and soil properties (Y)	Correlation r	coefficients r^2%	Prediction equations
Boron content of leaves	0.690**	47.6	$Y = 1.5 + 130.6 X$
Per cent increase in leaf-boron resulting from applied boron	—0.440**	19.4	
Soil Properties:			
Cation exchange capacity	0.430**	18.5	
Per cent base saturation	0.494**	24.4	$X = -0.03 + 0.005 Y$
Soil reaction	0.662**	43.8	$X = -0.44 + 0.12 Y$
Organic matter	0.099	1.0	
Extractable phosphorus	0.576**	33.2	
Extractable calcium	0.724**	52.4	
Extractable magnesium	0.748**	56.0	
Extractable potassium	0.292*	8.5	
Extractable sodium	0.061	0.4	

*Significant at the 5% level.

**Significant at the 1% level.

A significant positive correlation (0.690) was obtained between the boron content of cotton leaves and the native boron content of soils. This relationship is illustrated in Figure 1. The boron content of the leaves was a fairly reliable indicator of the soil's ability to supply boron to the plant. The concentration of boron in cotton leaves was approximately 130 times the content of hot-water-extractable soil boron.

A significantly negative relationship, r = —0.440, was calculated between the native boron content of the soil and the per cent increase in the boron concentration of cotton leaves resulting from the application of boron. The application of boron increased the boron content of the leaves of cotton plants growing on all soils. However, as the boron content of the soil increased, the percentage increase in the boron content of the leaves declined.

The correlation coefficients presented in Table 6 indicate that there were significant positive relationships between hot-water-extractable soil boron and cation exchange capacity, per cent base saturation, and soil reaction. Increases in the cation exchange capacity, per cent base saturation, and soil reaction were accompanied by increases in the boron content of the soils under investigation.

The relationships between hot-water-extractable soil boron and the per cent base saturation or soil reaction are illustrated in Figures 2 and 3.

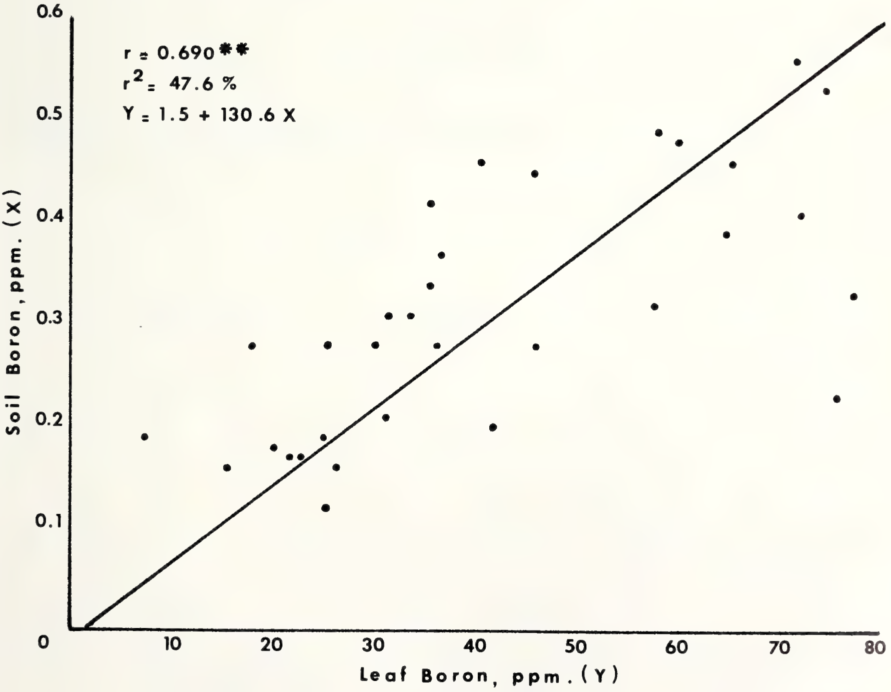


FIGURE 1.—The effect of hot-water-extractable soil boron on the boron content of cotton leaves.

There was no statistical relationship between hot-water-extractable soil boron and organic matter. This is contrary to the findings of Anderson and Boswell (*2*), Kowalczuk (*18*), and Wear (*40*), who reported significant associations between soil boron and organic matter. Most of the soils used in this investigation were consistently low in organic matter, and this chemical soil property was not associated with the content of soil boron.

Significant positive relationships were also calculated between soil boron and extractable phosphorus, calcium, magnesium, and potassium (Table 6). The data in Table 2 indicate that many of the alluvial soils of the Mississippi and Red rivers contained high amounts of phosphorus and cations, as well as inordinately high amounts of water-soluble boron, while the Coastal Plain soils, the Mississippi Terrace soils, and alluvial soils of the Ouachita River and distributaries of the Arkansas River tended to have lower contents of these plant nutrients. The correlation coefficients calculated between soil boron and extractable phosphorus, calcium, magnesium, and potassium do not appear to show a cause and effect relationship.

The distribution of hot-water-soluble boron at varying depths in the Hebert very fine sandy loam, the Yahola very fine sandy loam, and the Norwood silt loam is presented in Figure 4.

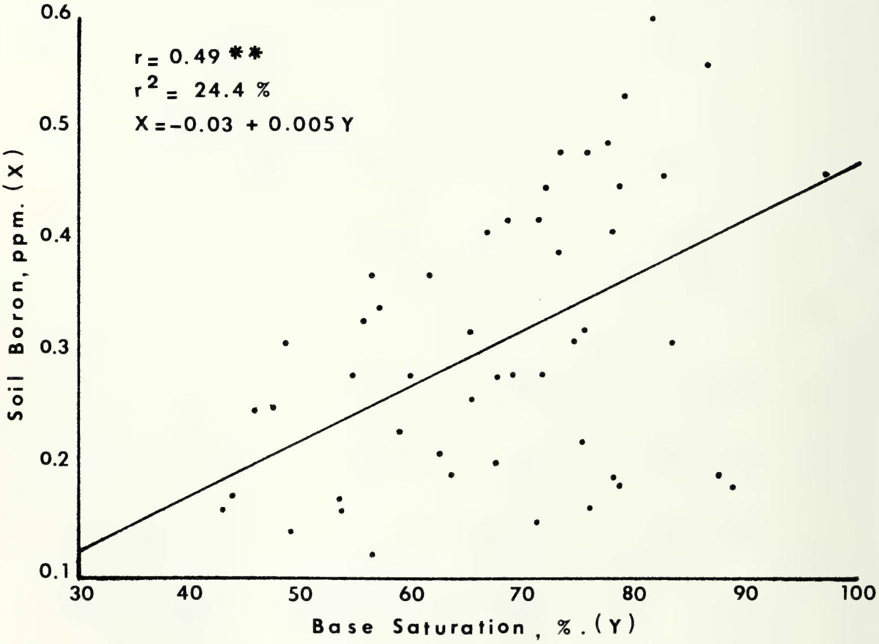


FIGURE 2.—The relationship between hot-water-extractable soil boron and the per cent base saturation of soils.

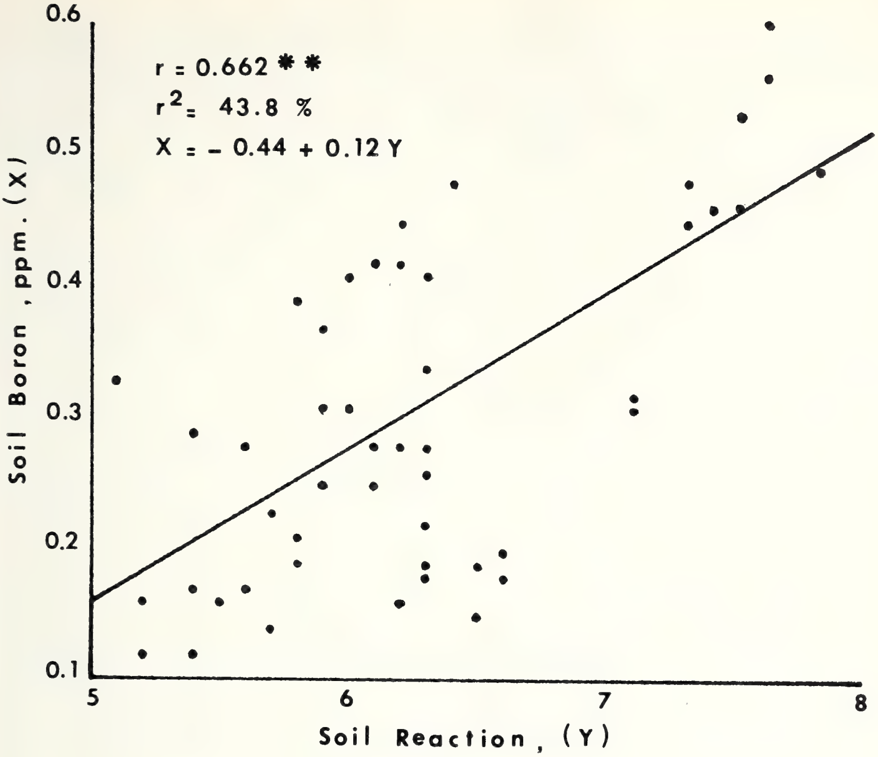


FIGURE 3.—The relationship between hot-water-extractable soil boron and soil reaction.

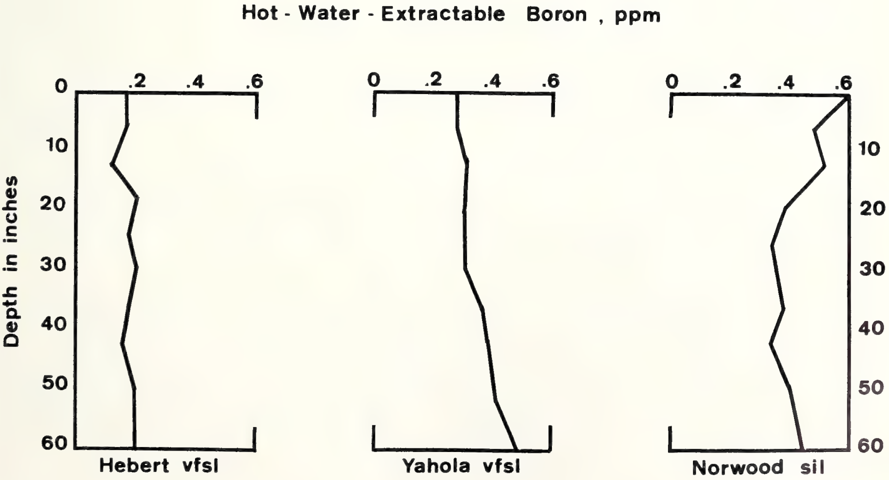


FIGURE 4.—The distribution of hot-water-extractable boron in three soils.

The Hebert soil, experiment number 26, contained a relatively low amount of hot-water-soluble boron, 0.2 ppm or less, throughout the soil profile. A highly significant increase of 726 pounds of seed cotton per acre was obtained from applied boron on this soil. The Yahola soil, experiment number 36, contained approximately 0.3 ppm of boron to a depth of 30 inches. From the 30- to 60-inch depth there was a progressive increase in the content of hot-water-soluble boron in the Yahola soil. A yield response to applied boron was not obtained on this soil. The surface soil of Norwood silt loam, experiment number 46, contained 0.6 ppm of hot-water-soluble boron. Relatively high amounts of soluble boron were present in the Norwood soil to a depth of 60 inches. The application of boron to the Norwood soil resulted in a yield reduction of 223 pounds of seed cotton per acre.

The alluvial surface soils of the Red River used in this investigation contained from 0.23 ppm to 0.60 ppm of hot-water-soluble boron. The application of boron resulted in reduced yields of cotton on 60 per cent of the soils. The larger reductions in yield occurred on soils containing the higher amounts of hot-water-soluble boron.

Summary and Conclusions

During a five-year period (1963-1967) 59 field experiments with boron on cotton were conducted at 49 locations in Louisiana to determine the effects of applied boron on the yield and on the boron concentration of cotton leaves. Attempts were also made to relate the boron contents of the soils and plant tissue with certain chemical soil properties. From the data obtained over a five-year period, the following conclusions were drawn.

1. There was a significant increase in yield of cotton from the application of boron at three of 49 experiment locations. Increased yield resulting from the application of boron occurred on Hebert and Pulaski very fine sandy loam in Morehouse Parish and on Gilead sandy loam in Lincoln Parish. The hot-water-extractable soil boron content of each of these soils was 0.19 ppm. This concentration of soil boron was considered to be critically low for cotton. However, the boron content of the surface soils was not the only criterion for predicting a response by cotton to applied boron. The hot-water-soluble boron content of the subsoil should also be considered.

2. The boron content of all of the soils ranged from 0.12 ppm to 0.60 ppm, with an average of 0.31 ppm. The alluvial soils of the Mississippi and Red rivers contained the higher amounts of hot-water-extractable boron, while the boron content of soils of the Coastal Plain and Mississippi Terrace and alluvial soils of the Ouachita River and distributaries of the Arkansas River were lower.

3. The boron concentration of the top-mature cotton leaves on plants growing on soils that did not receive an application of boron

ranged from 7.2 ppm to 111.4 ppm. The concentration of boron in the cotton leaves, below which a response to boron would be expected, appeared to be about 15 ppm. The application of one pound of boron per acre increased the boron concentration of the leaves of cotton plants growing on all of the soils. The increase in the boron concentration of the cotton leaves resulting from the application of boron ranged from 2.3 per cent to 191.7 per cent, with an average of 30.5 per cent.

4. There was a highly significant relationship ($r = 0.69$) between hot-water-extractable soil boron and the boron concentration of the cotton leaves. There were also significant positive relationships between hot-water-extractable soil boron and cation exchange capacity, per cent base saturation, soil reaction, and dilute-acid-extractable phosphorus, calcium, magnesium, and potassium. The correlation coefficients between hot-water-extractable soil boron and organic matter and extractable sodium were not significant. The correlation coefficients calculated did not appear to show a cause and effect relationship.

5. A reduction in the yield of cotton resulting from the boron application was obtained in nine of the 15 experiments conducted on alluvial soils of the Red River. The content of boron in these soils ranged from 0.23 ppm to 0.60 ppm. The larger yield reductions attributed to the boron treatment occurred on soils containing the higher amounts of hot-water-extractable boron.

6. There does not appear to be a critical need for supplementary boron fertilization of cotton in Louisiana. However, there are some soils in the Coastal Plains and in the floodplain of the Ouachita River and distributaries of the Arkansas River where a yield response to applied boron may be obtained.

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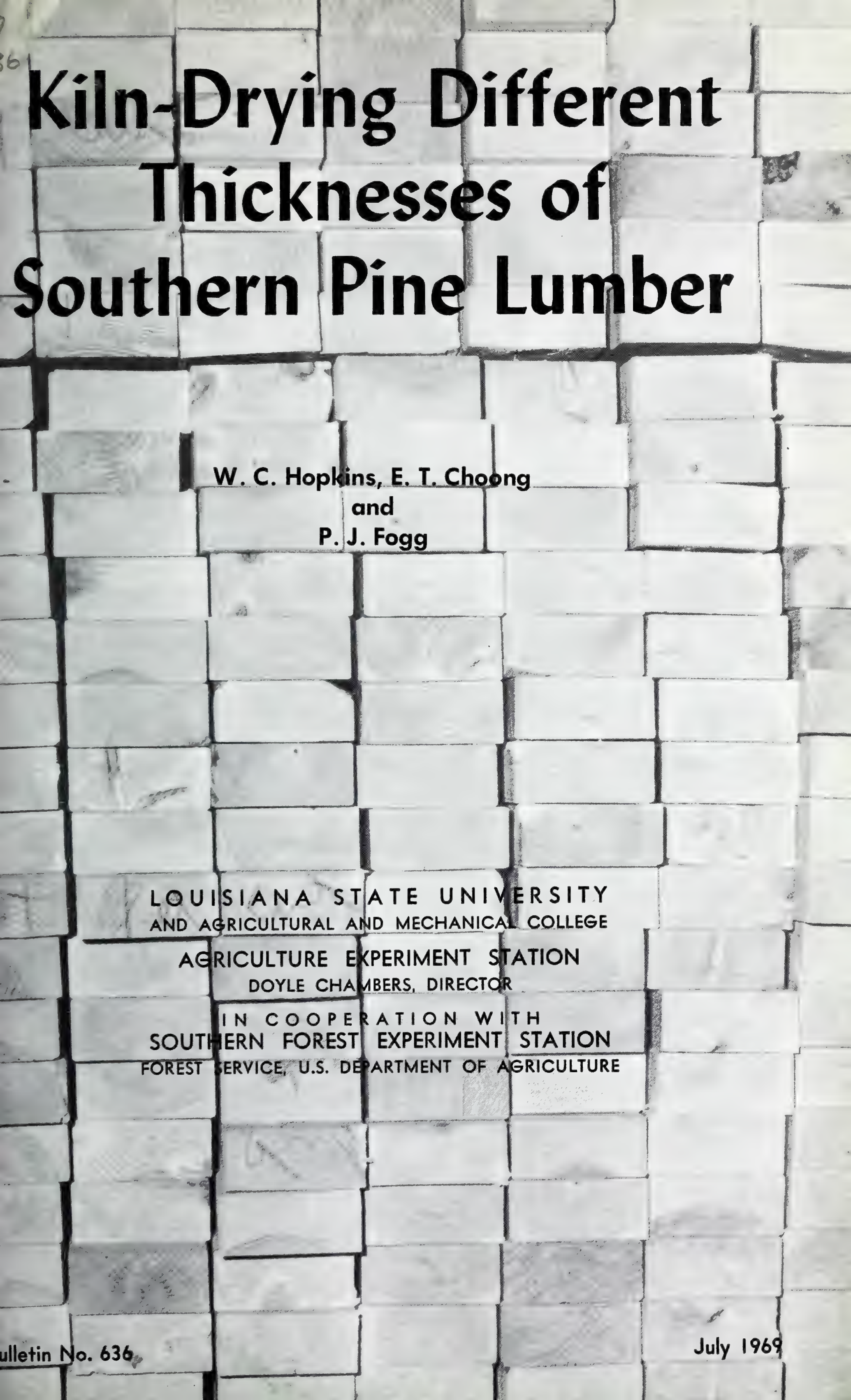

Kiln-Drying Different Thicknesses of Southern Pine Lumber

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Summary

The primary objective of this study was to compare the drying time and amount of seasoning degrade of 3/4-inch and 6/4-inch southern pine lumber with that of 4/4-inch and 8/4-inch lumber when all thicknesses were dried by typical kiln schedules. Additional objectives were to gain an indication of the feasibility of drying the thinner lumber, and of the associated reduction in costs and increase in production.

One 90-piece charge of each of the four thicknesses was dried in an experimental kiln by each of three schedules. The schedules selected for the 3/4-inch and 4/4-inch lumber were the same (mild, AS11-BK6; moderate, AS11-AK6; and severe, AS12-AK8). Identical schedules were also selected for the 6/4-inch and 8/4-inch lumber (mild, AS10-AK4; moderate, AS11-AK6; and severe, AS12-AK8). Each piece of lumber was weighed, measured, and checked before and after drying for warping defects and shrinkage. Casehardening was also checked on 10 samples, and the degree of surface checking was measured on another 10 samples from each charge.

Generally, 3/4-inch lumber not only dried more rapidly than 4/4-inch lumber with the same schedules, but did so without any significant increase in drying defects. In the case of 6/4-inch lumber, however, the more rapid drying, especially under the most severe schedule, was accompanied by an increased amount and severity of drying defects. This result indicates the need for use of more moderate schedules for drying 6/4-inch lumber than for 8/4-inch lumber.

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W. C. Hopkins, E. T. Choong and P. J. Fogg*

Introduction

Present practice in the southern pine industry is to manufacture lumber in 4/4-inch and 8/4-inch thicknesses. For many uses, however, 3/4-inch and 6/4-inch lumber would be equally good, and substantial increases in the number of pieces and surface area obtainable from a given size log would result. For example, a 15-inch log sawed into 4/4-inch lumber by a saw taking a 1/4-inch kerf yields 12 boards. If the same log is sawed into 3/4-inch lumber with the same saw, it yields 15 boards. Also, the cost of kiln-drying should be substantially less with thinner lumber. A kiln of a given capacity holds 17 per cent more pieces of 3/4-inch lumber than of 4/4-inch lumber, when using 3/4-inch stickers. Presumably, too, it would take less time to dry the thinner pieces. Seventy-two hours is the minimum time required to dry 4/4-inch southern pine lumber in a modern dry kiln. In a year with 300 working days, 100 charges can be processed through a kiln. If the 72-hour drying time could be reduced to 64 hours, 112.5 charges could be processed. Since each charge would contain 17 per cent more pieces, kiln output over the year could be increased by 32 per cent.

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This study was conducted to determine the feasibility of drying 3/4-inch and 6/4-inch lumber, from the standpoint of drying time and seasoning degrade, as a means of reducing manufacturing cost and increasing product yield without diminishing lumber quality.

Materials and Procedure

Kiln charges, three each of 3/4-inch, 4/4-inch, 6/4-inch, and 8/4-inch southern pine lumber, were dried in a steam-heated, internal-fan kiln at Louisiana State University. The experimental kiln was equipped with a recorder controller to maintain drying conditions called for in the drying schedule. The air flow, measured at the leaving-air side, was about 450 linear feet per minute. The air circulation was reversed at 4-hour intervals.

Each kiln charge consisted of 90 pieces of No. 2 Common or better, each 6 inches wide and 8 feet long. Six pieces in each charge were selected to provide moisture content samples. The kiln pile was made up of 12 courses, 4 feet wide. Each course contained eight pieces. No space was left between the edges of the lumber, but courses were separated by 3/4-inch stickers placed on 2-foot centers. To prevent warping, especially in the upper courses, each charge was suitably weighted with iron bars to distribute a total weight of 4,000 pounds on the bottom layers. A typical charge, in place in the kiln, is shown in Figure 1.

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The lumber for each charge was obtained at random from the green chain of a medium-sized sawmill in Southeast Louisiana. Pieces which included heartwood were excluded insofar as possible. Defects in individual pieces, such as checks or splits, were noted before drying so that degrade that developed during drying could be properly evaluated. Moisture content of the lumber for various charges ranged from 50 to 125 per cent.

In order to observe the process of drying, six end-coated samples, 30 inches long, were selected from the original supply of lumber for each kiln run. Three of the samples were placed on the entering-air side of the pile, the other three on the leaving-air side. On each side, these samples were located in the second, seventh, and eleventh courses (Fig. 2). Calculated oven-dry weights were computed from two 3/4-inch wafers sawed from one end of each sample. These values were used to determine the moisture content of the samples during drying by periodically reweighing the samples at each change in the drying schedule. A Pennsylvania scale was used to weigh each sample to the nearest one-hundredth of a pound.

Shrinkage and drying defects were evaluated by measurement of length, width, thickness, and warp of each piece of lumber before and after drying. The length of the piece was measured to the nearest thirty-second of an inch with a ruler, along a line extending from the mid-point of the width at one end to the mid-point of the width at the other end. The width and thickness of the board were measured to the nearest one-hundredth of an inch; the width was measured at the mid-point of the length, and the thickness at mid-length and mid-width. Warp was evaluated by measuring for maximum bow, crook, cup, and twist to the nearest thirty-second of an inch. Bow and crook were determined by placing the edge at either end of the piece against a taut wire and measuring the maximum perpendicular distance from the wire to the face and edge of the piece, respectively. Cup was determined by measuring the distance from a steel straightedge placed across the width of the lumber to its face. Twist was ascertained by holding three corners of the lumber down on a plane surface and measuring the distance from the surface to the other corner of the piece. The methods of measuring bow, crook, and twist are illustrated in Figures 3, 4 and 5, respectively.

In addition, 10 sample pieces, picked at random from each charge, were dressed on two surfaces to examine the extent of checking. A stress analysis was also made by sawing each of 10 randomly selected samples from each charge into two pieces and evaluating the nature of the stress (casehardening) developed after drying.

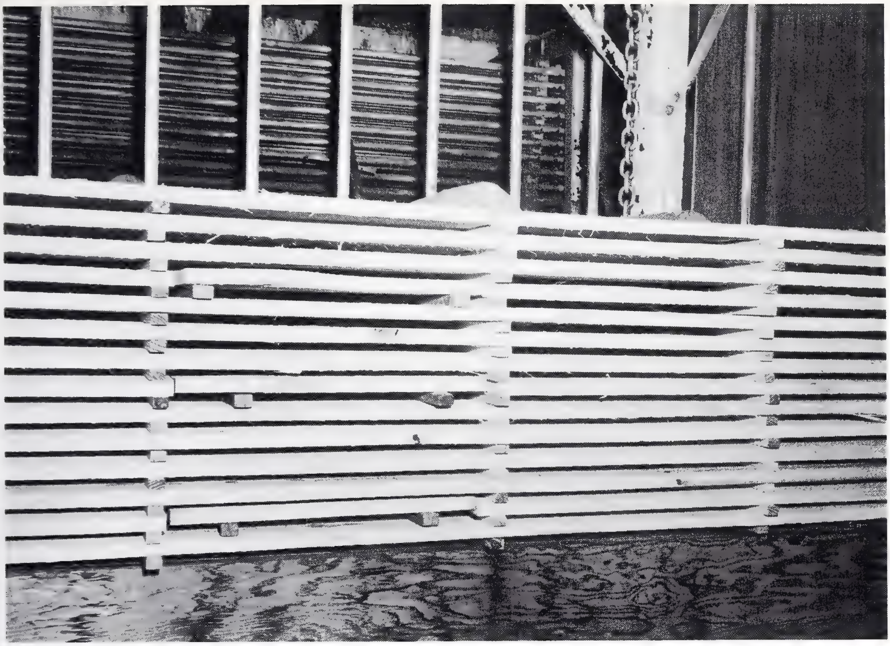

FIGURE 1.—Kiln charge in place.

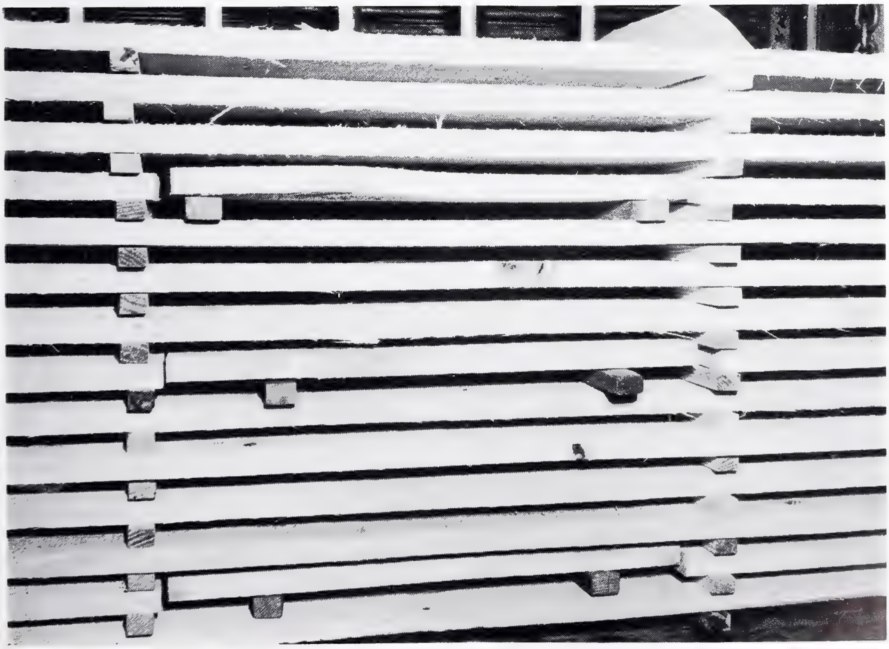

FIGURE 2.—Sample pieces in place in kiln pile.

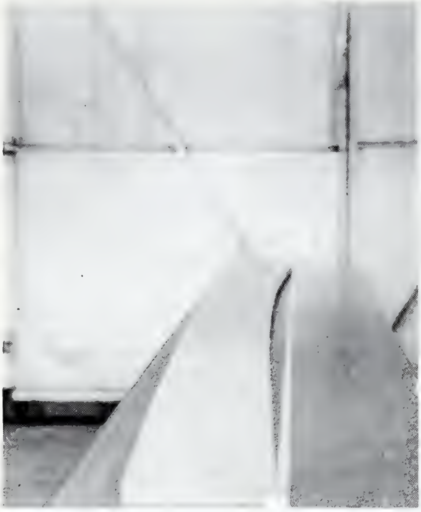

FIGURE 3.—Board in position for measurement of bow.

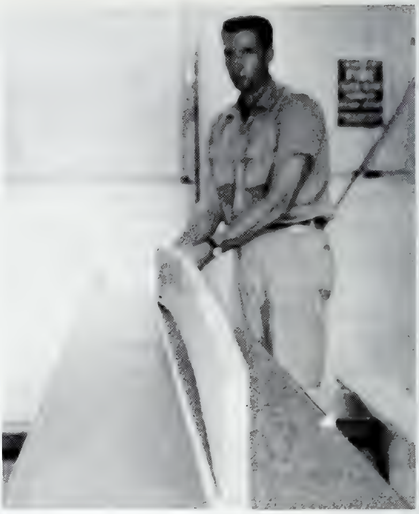

FIGURE 4.—Measurement of crook.

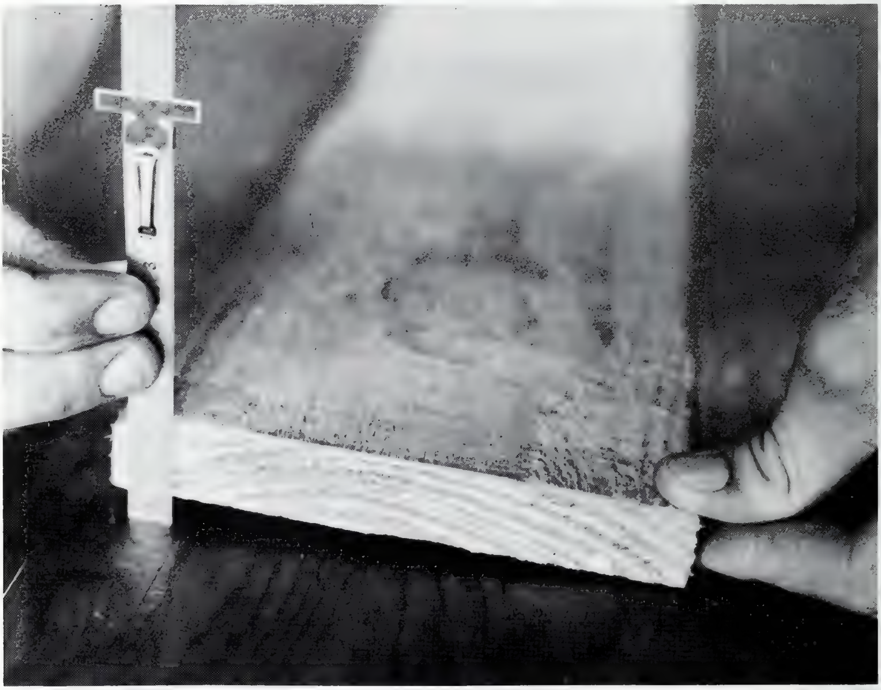

FIGURE 5.—Measurement of twist.

Kiln Conditions

Three different drying schedules were used with each thickness class, so that each schedule could be applied in a separate run. These schedules were obtained from a standard dry kiln manual.[1] Altogether, 12 different kiln runs were made. The code indices of kiln schedules for these runs are shown in Table 1.

The three drying schedules for 3/4-inch and 4/4-inch lumber are shown in Table 2. The first schedule (AS11-BK6) is an average commercial time schedule for upper grade 4/4-inch pine lumber, which ends with a 30° F. depression at 200° F. It is designed to achieve rapid drying under a relatively mild initial temperature condition. The second schedule (AS11-AK6) is intermediate in severity, requiring a more rapid change in depression. The third schedule (AS12-AK8) is the most severe, with a long period at 200° F. and a large (50° F.) depression.

The three drying schedules for 6/4-inch and 8/4-inch lumber are shown in Table 3. The first schedule (AS10-AK4) is an average commercial time schedule for upper 8/4-inch pine lumber. The second (AS11-AK6) and third (AS12-AK8) schedules are more severe than the first. They were designed with the objective of bracketing the ability of the 8/4-inch lumber to withstand rapid kiln drying while observing the effect on the 6/4-inch lumber.

Results and Discussion

Drying Rates

The various drying conditions attained and the rate-of-drying curves for each schedule-thickness combination (kiln run) are shown in Figures 6 through 17 (Pages 16-21).

TABLE 1.—Code Number Indices of Drying Schedules Used for Lumber of Various Thicknesses in Different Runs

Run no.	Lumber thickness	Drying schedule		
		Schedule	Code index	Severity
1	3/4	A	AS11-BK6	Mild
2	3/4	B	AS11-AK6	Moderate
3	3/4	C	AS12-AK8	Severe
4	4/4	A	AS11-BK6	Mild
5	4/4	B	AS11-AK6	Moderate
6	4/4	C	AS12-AK8	Severe
7	6/4	D	AS10-AK4	Mild
8	6/4	E	AS11-AK6	Moderate
9	6/4	F	AS12-AK8	Severe
10	8/4	D	AS10-AK4	Mild
11	8/4	E	AS11-AK6	Moderate
12	8/4	F	AS12-AK8	Severe

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[1] E. F. Rasmussen (1961). Dry Kiln Operator's Manual, Agricultural Handbook No. 188, U. S. Department of Agriculture, U. S. Forest Service, Washington, D. C. 197 p.

TABLE 2.—Schedules for Drying 3/4-Inch and 4/4-Inch Pine Lumber

Time	Dry bulb temperature	Wet bulb depression	Wet bulb temperature
Hours		°F.	
		Schedule A (AS11-BK6)	
0-12	165	15	150
12-24	170	15	155
24-36	175	20	155
36-48	180	20	160
48-60	190	25	165
60-72	190	25	165
72-	200	30	170
		Schedule B (AS11-AK6)	
0-12	170	15	155
12-24	175	20	155
24-36	180	25	155
36-48	190	30	160
48-60	190	30	160
60-72	200	35	165
72-	200	50	150
		Schedule C (AS12-AK8)	
0-12	170	20	150
12-24	175	25	150
24-36	180	30	150
36-48	190	35	155
48-60	190	43	147
60-72	200	50	150
72-	200	50	150

The average drying time at various fractions of moisture in wood (E values) and the final average equilibrium moisture content (EMC) obtained are presented in Table 4. The time to reach E = 0 is somewhat superficial due to the effect of stress relaxation in wood under a constant environmental condition;[2] hence, E = 0.04, which represents 96 per cent of the moisture removed from the wood, should be a better indication of total drying time. For example, Figure 6 shows that the total drying time required to reach an EMC of 7 per cent is 84 hours; yet the drying time required to reach 8 per cent moisture at E = 0.04 is only about half as long (44 hours). It should take only an additional 12 hours for degrade control and equalization treatment.

In drying both 3/4-inch and 4/4-inch lumber, the drying rate (per cent moisture removed per hour) at E = 0.5 is slowest in schedule A, intermediate in schedule B, and fastest in schedule C. The drying rate for the thinner (3/4-inch) lumber is consistently faster than that for the thicker (4/4-inch) lumber, even though the drying time at E = 0.5 in schedule C is greater for the thinner lumber than for the thicker lumber.

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[2] E. T. Choong and P. J. Fogg (1968). Movement of Moisture in Six Wood Species. Forest Products Journal 18(5):66-70.

TABLE 3.—Schedules for Drying 6/4-Inch and 8/4-Inch Pine Lumber

Time	Dry bulb temperature	Wet bulb depression	Wet bulb temperature
Hours		°F.	
		Schedule D (AS10-AK4)	
0-12	160	7	153
12-24	165	10	155
24-36	170	15	155
36-48	180	20	160
48-60	180	25	155
60-72	190	30	160
72-	190	35	155
		Schedule E (AS11-AK6)	
0-12	165	15	150
12-24	170	20	150
24-36	175	25	150
36-48	180	30	150
48-60	190	30	160
60-72	190	35	155
72-	200	50	150
		Schedule F (AS12-AK8)	
0-12	170	20	150
12-24	175	25	150
24-36	180	30	150
36-48	190	35	150
48-60	190	43	147
60-72	200	50	150
72-	200	50	150

This can happen because the E-value is a function of the initial moisture content of wood.

In drying 6/4-inch and 8/4-inch lumber, the drying rate at $E = 0.5$ is slowest in schedule D, and faster in both schedules E and F. The reason a moderate schedule (E) dries the 8/4-inch lumber faster than a more severe schedule (F) is probably due to the initial high wet bulb depression in schedule E (Fig. 16) followed by a lowering of this depression during the second stage of drying, when most of the free water in the wood near the surface has been removed. The effect of this kind of schedule on degrade was found to be less than that of the more severe schedule. A comparison of the drying rates for the two thicknesses shows that the thinner lumber tends to dry faster than the thicker lumber. The final equilibrium moisture content of these two lumber thicknesses, however, averages about 6 per cent higher than that of either the 3/4-inch or the 4/4-inch lumber, suggesting that the total drying time is actually longer than that indicated in Table 4.

Dimensional Change

Shrinkage in length, width, and thickness of lumber in terms of actual changes in dimensions from the green condition to moisture equilibrium

TABLE 4.—Drying Data for Pine Lumber of Different Thicknesses Dried with Different Schedules

Thickness class	Run no.	Schedule class	Avg. drying rate at E=0.5	Avg. drying time[1] E=0.5	E=0.04	E=0.0	Avg. EMC
Inch			% MC/Hr.	Hours			%
3/4	1	A	1.7	13	44	84	7
	2	B	3.9	14	43	84	6
	3	C	4.2	15	40	72	3
4/4	4	A	1.4	17	50	84	3
	5	B	2.5	19	48	84	4
	6	C	3.7	12	42	72	4
6/4	7	D	0.8	29	65	72	10
	8	E	1.8	24	50	60	11
	9	F	1.8	22	43	48	13
8/4	10	D	0.9	51	91	96	12
	11	E	1.4	32	77	84	13
	12	F	1.2	32	76	84	10

[1] E is fraction of moisture in wood, which is the difference between current moisture content (MC) and equilibrium moisture content (EMC), divided by the difference between original moisture content and equilibrium moisture content.

are given in Table 5. These data are averages derived from measurement of 90 pieces of lumber in each kiln charge. Since the material consisted almost entirely of flat-sawed lumber, the width and thickness represent the tangential and radial direction of the grain, respectively. The effects of the drying schedule and thickness on shrinkage in the three directions were statistically analyzed (Table 6). With the exception of the shrinkage in length in the 6/4-inch and 8/4-inch stock, all shrinkage values were affected by the drying schedule. Furthermore, all shrinkage values except those in length in the 3/4-inch and 4/4-inch stock were also affected by the thickness of the lumber. Shrinkage in thickness of 3/4-inch lumber was 63 per cent of that of 4/4-inch lumber. There was less shrinkage in length and more shrinkage in width in 6/4-inch than in 8/4-inch lumber.

It is apparent from Table 5 that almost all shrinkage values in the 6/4-inch and 8/4-inch lumber were somewhat lower than in the 3/4-inch and 4/4-inch lumber, because the thicker lumber had a higher equilibrium moisture content. It is also shown in Table 5 that mild schedules (A and B) caused the least shrinkage in all of the three directions, whereas severe schedules (C and F) caused the most shrinkage. However, these differences were not great. The reason for these shrinkage differences is probably that large drying stresses occur when a schedule is severe, causing a great amount of set to develop in tension in the outer portion of the wood. The resultant effect is a large compression set in the inner wood, exerting a significant influence on total shrinkage.

Warp

Data on warping defects are given in Table 7. The effects of the drying schedule and lumber thickness on these defects were statistically analyzed (Table 8). In the 3/4-inch and 4/4-inch lumber, the more severe drying schedule (C) contributed to more bowing, crooking, and cupping than the less severe schedules (A and B); but the extent of

TABLE 5.—Shrinkage in Length, Width, and Thickness of Lumber During Kiln-Drying from the Green Condition

Schedule and thickness	Average shrinkage (green to EMC)					
	Length		Width		Thickness	
	Inch					
SCHEDULE A						
3/4-inch	.057	(0–.25)[1]	.270	(.13–.36)	.025	(0–.07)
4/4-inch	.072	(0–.25)	.284	(.15–.41)	.044	(0–.08)
SCHEDULE B						
3/4-inch	.062	(0–.38)	.356	(.17–.45)	.030	(0–.07)
4/4-inch	.076	(0–.11)	.321	(.17–.42)	.047	(0–.10)
SCHEDULE C						
3/4-inch	.151	(0–.53)	.345	(.19–.41)	.033	(0–.08)
4/4-inch	.119	(0–.46)	.370	(.13–.40)	.047	(0–.10)
SCHEDULE D						
6/4-inch	.046	(0–.28)	.153	(.03–.30)	.031	(0–.08)
8/4-inch	.076	(0–.59)	.066	(0–.34)	.023	(0–.09)
SCHEDULE E						
6/4-inch	.059	(0–.62)	.164	(.06–.32)	.042	(0–.09)
8/4-inch	.073	(0–.62)	.096	(0–.21)	.025	(0–.10)
SCHEDULE F						
6/4-inch	.067	(0–.28)	.153	(.03–.22)	.028	(0–.07)
8/4-inch	.078	(0–.69)	.146	(.06–.28)	.039	(0–.10)

[1] Ranges of values. In parentheses: first number is minimum, second number is maximum.

TABLE 6.—Effect of Schedule, Thickness, and Schedule-Thickness Interaction on Shrinkage in Length, Width, and Thickness

Independent variable	Shrinkage in		
	Length	Width	Thickness
3/4 and 4/4 lumber			
Schedule	**	**	**
Thickness	N.S.[1]	*	**
Interaction	*	**	N.S.
6/4 and 8/4 lumber			
Schedule	N.S.	**	**
Thickness	*	**	**
Interaction	N.S.	**	**

*Significant at 5% level of probability.
**Significant at 1% level of probability.
[1] Not significant.

TABLE 7.—Summary of Warping Defects Developed During Drying

Schedule and thickness	Warping defects (average value)			
	Bow	Crook	Twist	Cup
	1/32nd inch			
SCHEDULE A				
3/4-inch	1.3 (–7, +14)[1]	2.6 (–3, +19)	2.8 (–3, +10)	1.4 (0, +4)
4/4-inch	–0.5 (–19, +13)	2.4 (–4, +20)	3.3 (–6, +16)	1.7 (0, +4)
SCHEDULE B				
3/4-inch	3.3 (–3, +36)	2.6 (–4, +29)	2.8 (–3, +12)	1.1 (0, +4)
4/4-inch	1.1 (–13, +13)	3.4 (–2, +35)	3.2 (–3, +23)	1.1 (0, +3)
SCHEDULE C				
3/4-inch	2.6 (–13, +24)	6.3 (–3, +40)	1.3 (–2, +8)	1.4 (0, +4)
4/4-inch	3.5 (–11, +23)	4.2 (–2, +42)	3.2 (–4, +14)	2.5 (0, +5)
SCHEDULE D				
6/4-inch	0.6 (–5, +11)	0.7 (–4, +10)	4.7 (0, +28)	0.6 (0, +3)
8/4-inch	0.3 (–6, +8)	0.9 (–4, +6)	2.1 (0, +10)	0.0 (0, +1)
SCHEDULE E				
6/4-inch	1.1 (–16, +23)	2.1 (–5, +27)	3.1 (–2, +32)	0.6 (0, +3)
8/4-inch	1.1 (–17, +9)	2.7 (–4, +25)	2.6 (–3, +21)	0.0 (0, +2)
SCHEDULE F				
6/4-inch	0.1 (–6, +10)	1.2 (–2, +21)	4.7 (–2, +15)	0.6 (0, +2)
8/4-inch	0.1 (–8, +9)	2.6 (–3, +36)	4.5 (–3, +20)	0.0 (0, +0)

[1] Ranges of values. In parentheses: first number is minimum (negative value indicates a decrease in the defect during drying); second number is maximum.

TABLE 8.—Effect of Schedule, Thickness, and Schedule-Thickness Interaction on Development of Bow, Crook, Twist, and Cup

Independent variable	Warping defects			
	Bow	Crook	Twist	Cup
3/4 and 4/4 lumber				
Schedule	**	**	N.S.	**
Thickness	*	N.S.[1]	**	**
Interaction	**	*	N.S.	**
6/4 and 8/4 lumber				
Schedule	N.S.	**	*	N.S.
Thickness	**	*	**	**
Interaction	**	N.S.	N.S.	N.S.

*Significant at 5% level of probability.
**Significant at 1% level of probability.
[1] Not significant.

twist was almost the same in all three schedules. In the 6/4-inch and 8/4-inch lumber, the severity of the drying schedule affected only crooking and twisting. Generally, more warp developed in the 4/4-inch lumber than in the 3/4-inch lumber. In the thicker group, the 6/4-inch lumber had greater seasoning degrade than the 8/4-inch lumber. Normally, warping is caused by differential shrinkage behavior in material that contains natural defects, such as knots or cross-grain, and is not solely attributable to the atmospheric condition under which the wood dries if all boards are properly stacked. However, the severity of the drying schedule, especially when high temperature is involved, is closely related to set and shrinkage, which in turn affect the degree of warpage. Furthermore, unbalanced moisture content as a result of overdrying may render the wood more susceptible to warping.

Casehardening

The degree of casehardening in 10 samples of each thickness from each kiln charge is shown in Table 9. The results appear somewhat contradictory. Generally, more than 50 per cent of the samples examined developed a moderate to severe casehardening condition in every kiln run. Despite the tendency for casehardening to develop somewhat more severely in either the mild or moderate schedule, concrete evidence of the causes is lacking due to the limited sampling and uncontrollable variations in drying schedules. Casehardening occurs early in the drying period as a result of tension set established in the exterior layers of the wood. This condition is usually associated with drying surfaces too rapidly, either because the temperature is too high or the humidity is too low, or both. It can also result from uneven drying, when poor air circulation causes too large a fluctuation in temperature and humidity. Casehardening is usually prevented by restricting steep moisture gradients in wood during drying. The development of set, however, is a function of both

TABLE 9.—Frequency and Severity of Casehardening

Schedule and thickness	Degree of casehardening		
	None	Slight	Moderate to severe
	. . . .	Percent of boards	. . . .
SCHEDULE A			
3/4-inch	—	40	60
4/4-inch	—	40	60
SCHEDULE B			
3/4-inch	—	10	90
4/4-inch	—	10	90
SCHEDULE C			
3/4-inch	—	40	60
4/4-inch	—	20	50
SCHEDULE D			
6/4-inch	—	—	100
8/4-inch	40	10	50
SCHEDULE E			
6/4-inch	10	30	60
8/4-inch	30	10	50
SCHEDULE F			
6/4-inch	10	—	90
8/4-inch	—	10	90

time-temperature and time-load effects.[3] This phenomenon, as it relates to drying behavior, is not yet understood.

Surface Checking

The frequency and severity of surface checking that occurred in 10 samples in each kiln charge are presented in Table 10. Both the 3/4-inch and the 4/4-inch lumber had very few surface checks when dried with schedule A, but more checks developed with schedules B and C because higher temperatures and lower humidities were used in these schedules. The resultant effects of lower humidity are a steeper moisture gradient and greater tensile stress in the surface layers of the wood. When these effects are accompanied by high temperature, the wood is further weakened so that more surface checks develop. A comparison shows that the 4/4-inch lumber developed more checks than the 3/4-inch lumber, probably because of a steeper moisture gradient in the thicker lumber when the drying rates for the two thicknesses were the same.

In the 6/4-inch and 8/4-inch lumber group, the thinner lumber had more checks. The reason may be the drying rate of the 8/4-inch lumber, which was slower and resulted in less moisture gradient than in the 6/4-inch lumber. The severe drying schedule likewise caused more checking than the mild drying schedule.

TABLE 10.—Frequency and Severity of Surface Checking

Schedule and thickness	Number of checks			
	0	1–5	6–15	16+
	Percent of board faces			
SCHEDULE A				
3/4-inch	95	5	0	0
4/4-inch	95	5	0	0
SCHEDULE B				
3/4-inch	90	0	10	0
4/4-inch	80	15	5	0
SCHEDULE C				
3/4-inch	95	5	0	0
4/4-inch	70	5	25	0
SCHEDULE D				
6/4-inch	0	90	10	0
8/4-inch	65	30	5	0
SCHEDULE E				
6/4-inch	10	75	10	5
8/4-inch	85	10	5	0
SCHEDULE F				
6/4-inch	0	80	20	0
8/4-inch	15	10	65	10

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[3] J. M. McMillen (1958). Stresses During the Drying of Lumber. U.S. Forest Products Laboratory, Report No. 1652, Madison, Wisconsin.

Conclusions

From this investigation the following conclusions are drawn:

1. Three-quarter-inch southern pine may be dried using schedules similar to those used for 4/4-inch lumber.

2. Such schedules (AS11-BK6, AS11-AK6, and AS12-AK8) resulted in faster drying rates and shorter drying times for 3/4-inch lumber as compared with those for 4/4-inch lumber.

3. Seasoning degrade (warping, casehardening, and checking) was generally less in 3/4-inch lumber than in 4/4-inch lumber, except in the case of casehardening under the more severe drying schedule.

4. Shrinkage in thickness of 3/4-inch lumber was 63 per cent of that of 4/4-inch lumber.

5. Six-quarter-inch lumber dried at considerably faster rates and in shorter times than 8/4-inch lumber under similar drying schedules.

6. The schedules used (AS10-AK4, AS11-AK6, and AS12-AK8) generally resulted in greater seasoning degrade (warping, casehardening, and checking) in 6/4-inch lumber than in 8/4-inch lumber, indicating the need for caution in selection of drying schedules for the thinner of these two thicknesses.

7. There was less shrinkage in length and more shrinkage in width in 6/4-inch lumber than in 8/4-inch lumber.

8. A moderate schedule is advisable for fast drying. However, 3/4-inch lumber can be dried using a more severe schedule without developing defects that exceed economically acceptable levels. A severe schedule is not advisable for 6/4-inch lumber because of excessive losses from degrade.

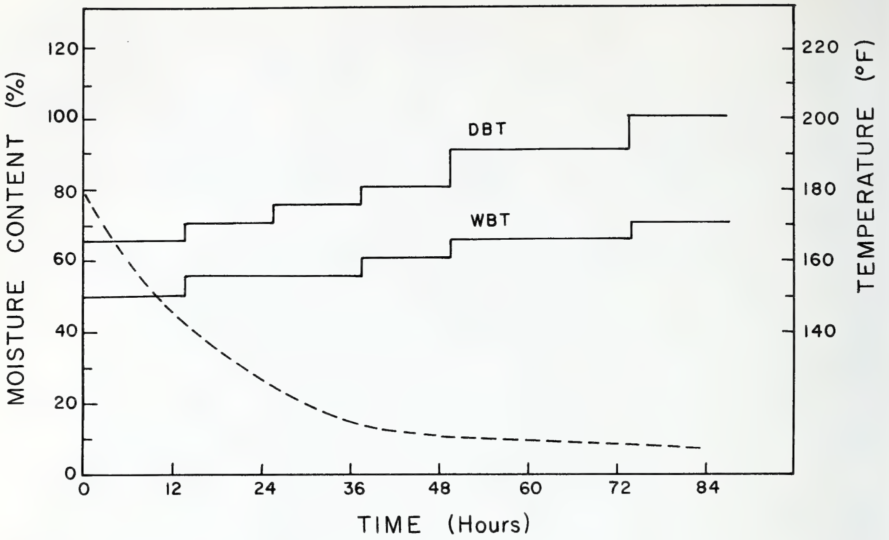

FIGURE 6.—Kiln schedule and drying rate. Schedule A, ¾-inch lumber.

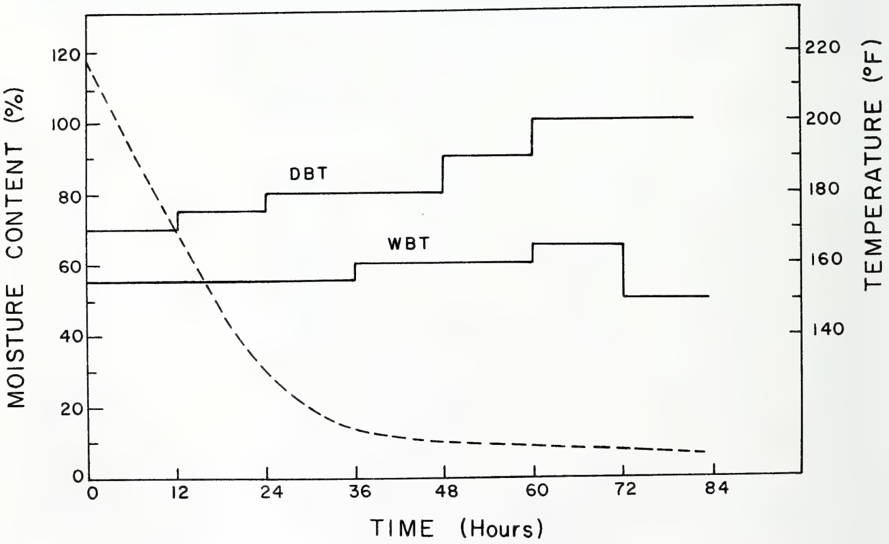

FIGURE 7.—Kiln schedule and drying rate. Schedule B, ¾-inch lumber.

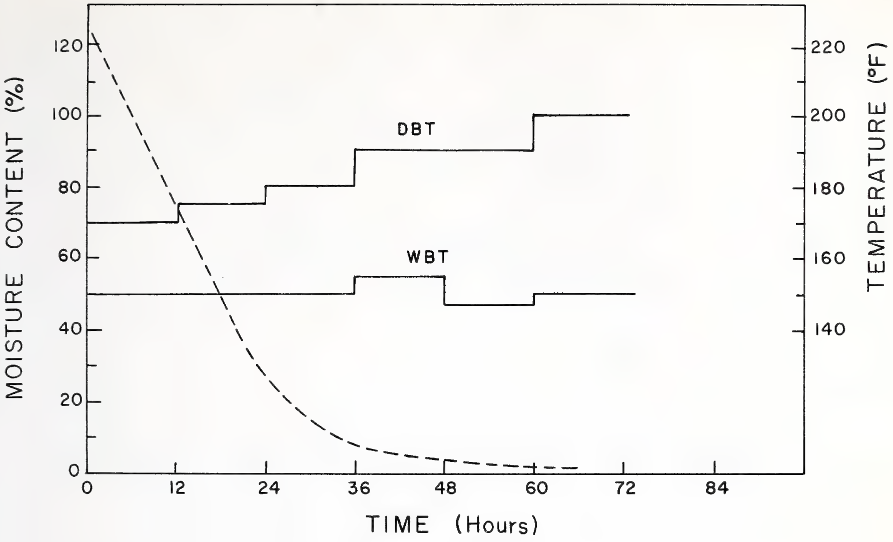

FIGURE 8.—Kiln schedule and drying rate. Schedule C, ¾-inch lumber.

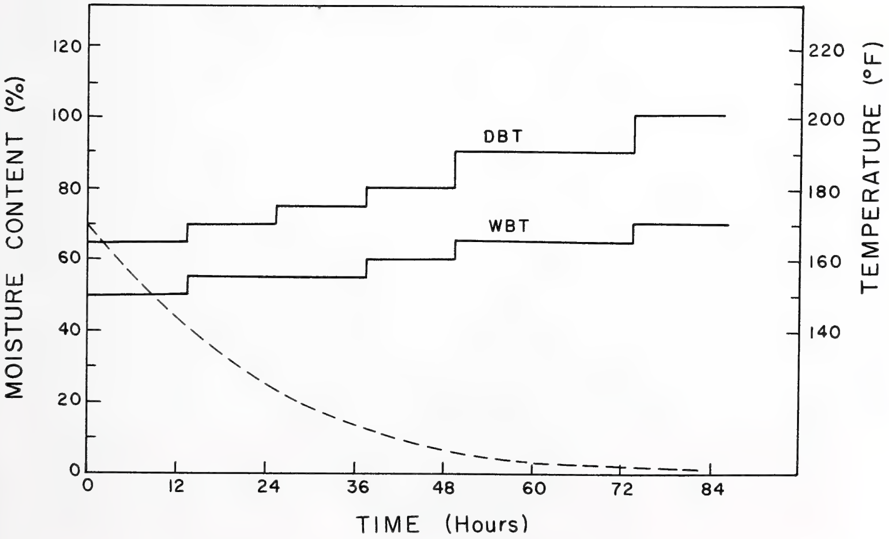

FIGURE 9.—Kiln schedule and drying rate. Schedule A, 4/4-inch lumber.

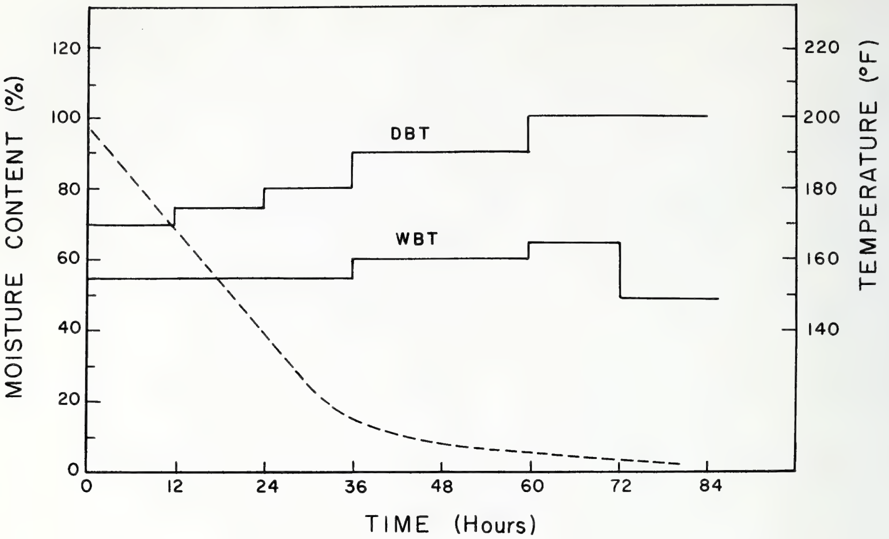

FIGURE 10.—Kiln schedule and drying rate. Schedule B, 4/4-inch lumber.

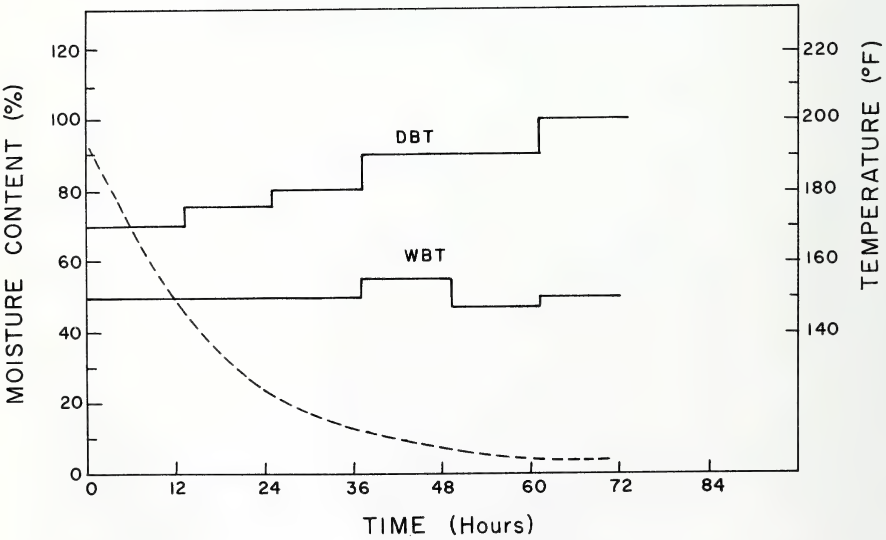

FIGURE 11.—Kiln schedule and drying rate. Schedule C, 4/4-inch lumber.

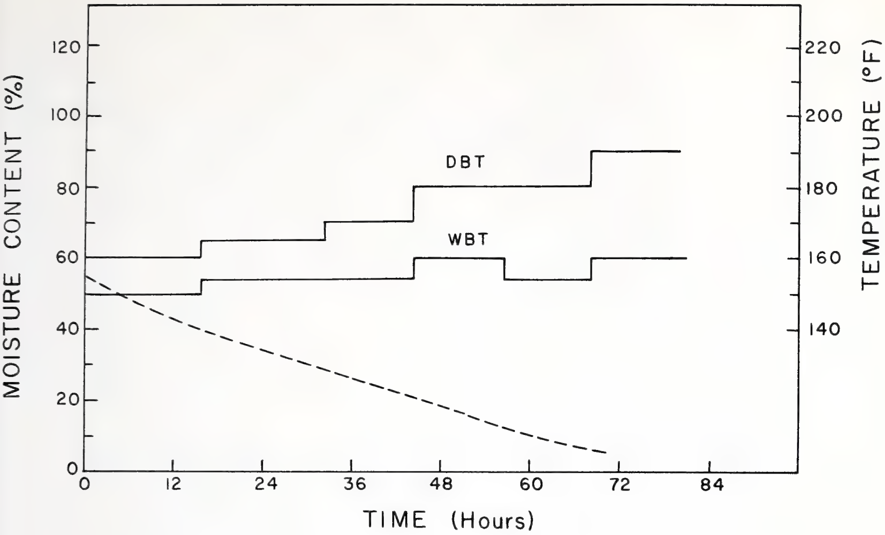

FIGURE 12.—Kiln schedule and drying rate. Schedule D, 6/4-inch lumber.

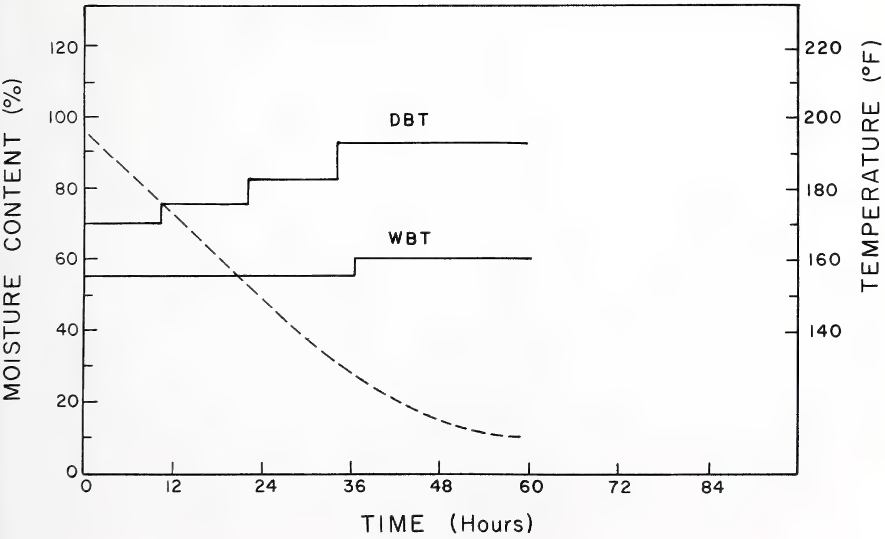

FIGURE 13.—Kiln schedule and drying rate. Schedule E, 6/4-inch lumber.

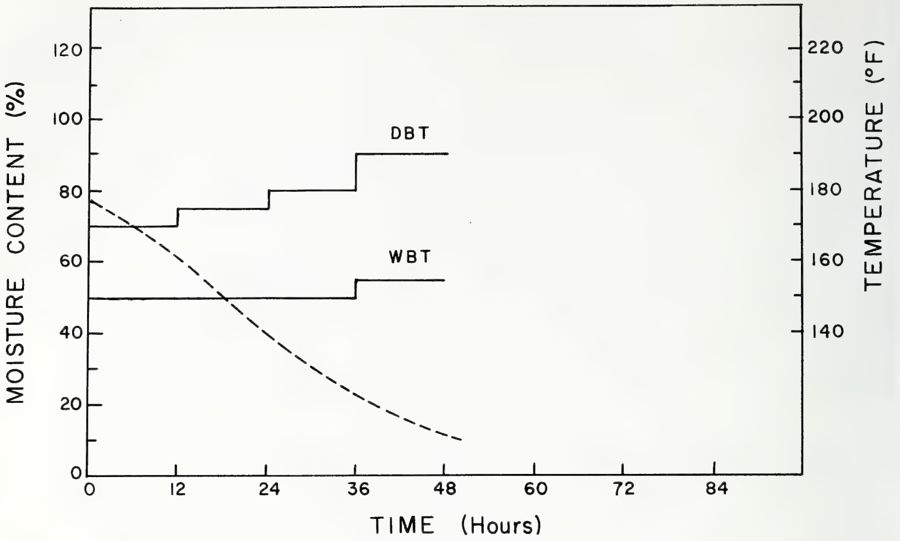

FIGURE 14.—Kiln schedule and drying rate. Schedule F, 6/4-inch lumber.

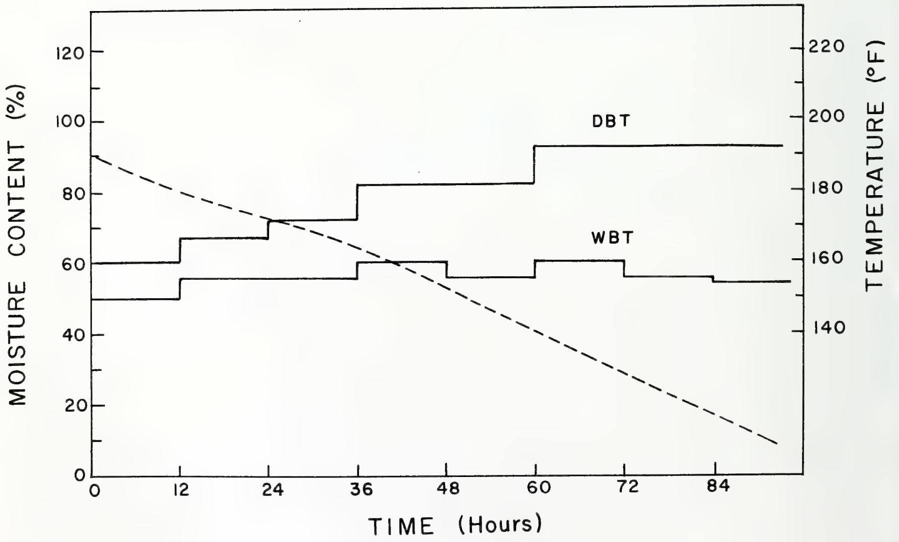

FIGURE 15.—Kiln schedule and drying rate. Schedule D, 8/4-inch lumber.

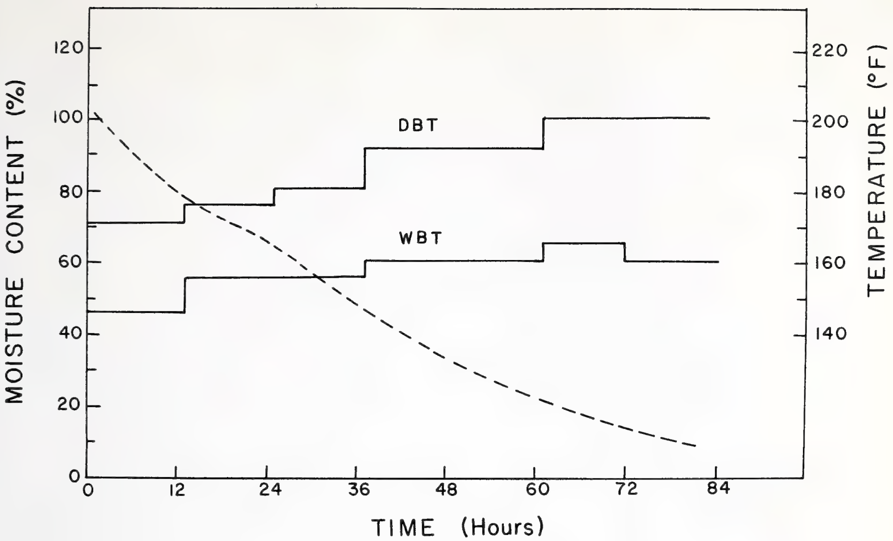

FIGURE 16.—Kiln schedule and drying rate. Schedule E, 8/4-inch lumber.

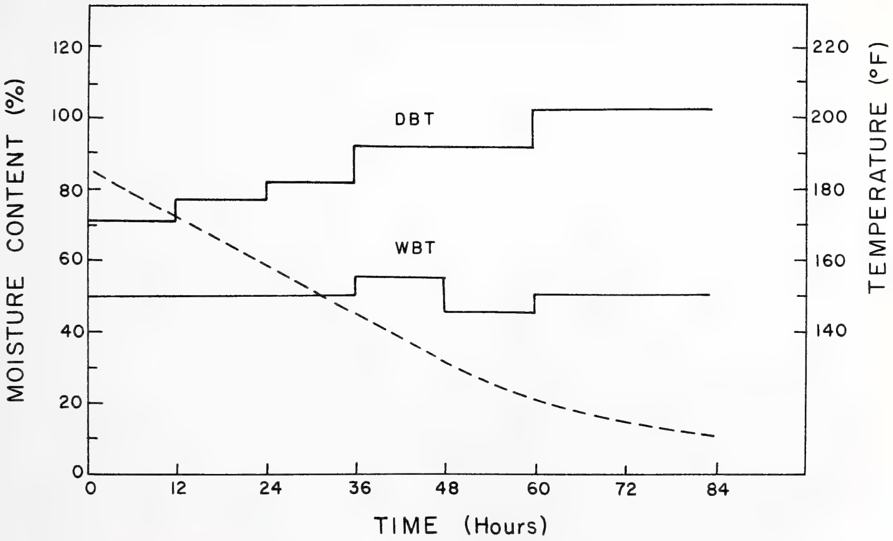

FIGURE 17.—Kiln schedule and drying rate. Schedule F, 8/4-inch lumber.

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The Availability and Distribution Of Health Personnel In Louisiana

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LOUISIANA REGIONAL MEDICAL PROGRAM
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Foreword

The study reported in this publication was funded through the Louisiana Regional Medical Program for Heart Disease, Cancer and Stroke. This monograph represents one of several similar publications to be completed by Dr. Bertrand, Mr. Baty, Mrs. Steelman and staff as part of a project related to "The Delineation of Health Care Regions Within the State of Louisiana."

The information published in these monographs should facilitate effective health care planning at all levels within the state.

The disparity between the pressures being brought to bear on the health care system by public demand and the resources within the system leave no obvious alternative other than effective broad-based health care planning.

Only if planning emanates from the grass roots level can the products of planning be expected to be implemented.

If these monographs stimulate more effective planning at the grass roots level, their purpose will be well served.

J. A. Sabatier, Jr., M.D.
Director, Louisiana Regional
Medical Program

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The Availability and Distribution Of Health Personnel in Louisiana*

CARL F. BATY, VIRGINIA P. STEELMAN AND ALVIN L. BERTRAND**

The importance of health and medical care to the well-being of a population is self-evident. In view of this fact, it is important that continuing studies of the availability of medical personnel be made. This report is designed to show the situation which exists in Louisiana. The information given provides a basis for evaluating the nature and extent of problems related to health care needs.

In reviewing the data presented in this report, it should be noted that certain factors related to current trends appear to be influencing the distribution of medical personnel. On the one hand, a proliferation of medical specialties and the increasing complexity and cost of medical practice make the larger clinics and hospitals the most efficient mechanisms for the delivery of optimal medical treatment. On the other hand, rapid urbanization and the accompanying relative depopulation of rural areas make even more observable and dramatic the problems of medical personnel distribution. It appears reasonable to expect that rural areas of Louisiana will not only continue to be relatively disadvantaged in regard to the statewide distribution of medical personnel, but will demonstrate an increasing disparity on this measure of well-being.

This study represents an investigation of the distribution of selected medical and paramedical personnel in both rural and urban areas of Louisiana. In addition, the situation in terms of availability and distribution of this type personnel is compared with that evidenced in the late 1940's.

Methodology

The data for this study were obtained from a wide range of sources. Membership lists for medical and paramedical associations were integrated with directories from state licensing or examining boards. Indices of personnel were developed from the prepared lists and related to population estimates for each parish.[1] Medical personnel-population ratios at the national level were compared with state ratios and utilized as indices of availability of medical personnel.[2] In order to show changes over time, current state and parish data were related to data taken from a 1950 study of medical personnel in Louisiana.[3]

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*This investigation was supported by the Louisiana Regional Medical Program (LRMP) with funds provided by the U.S. Public Health Service. The findings in this report are not to be construed as an official LRMP or USPHS position unless so designated by other authorized documents.

**Graduate Research Assistants and Professor, respectively, Departments of Sociology and Rural Sociology, Louisiana State University.

[1] Footnote 1 on Page 6.

[2] Footnote 2 on Page 6.

The basic unit of analysis for this study was the parish (county). Data were not readily available for other plausable units, such as urban places, wards, or census tracts, although analysis at these levels would have yielded meaningful results.

For analytical purposes, a distinction was made between rural and urban parishes. Rural parishes were delineated according to census classification as those which did not contain an incorporated or unincorporated place with a population of 2,500 or more in 1960. Parishes were arbitrarily designated as urban if they contained at least one urban area with a population of over 25,000 in 1960. This scheme of classification was designed to make rural-urban comparisons more meaningful. Altogether, 13 rural and nine urban parishes were delineated. The remaining 42 parishes can be seen as intermediate to these extremes.

In most cases more than one source of personnel data was available. Variations between sources were due to different methods of classification. Extreme variations are noted in the individual sections where they occur.

The distribution of medical and paramedical personnel given does not necessarily refer to all persons who were actively engaged in practice. Some persons maintaining membership in a given medical organization or certification in a health specialty were employed in other activities and others were retired. On the other hand, some practitioners were not registered for one reason or another. Each person reported as being licensed or certified was included although his or her precise employment status was not known.

Availability of Physicians

In 1967, there were 3,941 physicians residing in Louisiana who were licensed by the Louisiana State Board of Medical Examiners.[4] Approximately 97 per cent of these physicians were engaged in patient care.[5] The ratio of persons per physician in the state was 913. By comparison, there were 2,709 physicians in the state in 1950 and the persons-per-physician

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[1] Parish population projections were taken from quarterly publications of the Louisiana Department of Public Welfare. See: Louisiana Public Welfare Statistics, April, May, and June 1967 and April, May, and June 1968. These figures had been obtained by applying natural increases to census data and increasing or decreasing estimates for migration. These estimates were compared with parish population projections contained in: James R. Bobo, Sandra A. Etheridge and Norma L. Weed, *The Population of Louisiana*, Division of Business and Economic Research, College of Business Administration, Louisiana State University, New Orleans (1968). Interpolations of the parish projections for 1965 and 1970 were compared with welfare department estimates for 1967 and 1968. No excessive discrepancies were found.

[2] U.S. Public Health Service, *Health Resouces Statistics* (1968).

[3] Paul H. Price and Homer L. Hitt, *The Availability of Medical Personnel in Rural Louisiana*, Louisiana State University and Agricultural and Mechanical College, Agricultural Experiment Station, Bulletin No. 459, June 1951.

[4] Footnote 4 on Page 7.

[5] Footnote 5 on Page 7.

ratio was 985. The number of physicians increased approximately 45 per cent in this 18-year period. However, the persons-to-physician ratio improved by less than 10 per cent. Although this change represents a trend in the right direction, it is evident that the increase in number of physicians was, for the most part, absorbed by population increases.

In 1967, the national ratio of persons per physician was 639. The unfavorable position of Louisiana was indicated by the fact that the state ratio of 913 was approximately 40 per cent higher than the national ratio. Only one parish in the state, Orleans, had a persons-per-physician ratio below the national average. Six other parishes had a persons-to-physician ratio of less than 1,000 (Table 1 and Fig. 1). These included Caddo, Lafayette, East Baton Rouge, St. Tammany, Rapides, and Jefferson parishes.

TABLE 1.—Number of Physicians and Persons per Physician, by Parish, 1950 and 1967*

	1950			1967		
	No. of	Persons per Dr.		No. of	Persons per Dr.	
Parish	doctors	Ratio	Rank	doctors	Ratio	Rank
Acadia	30	1,567	13	29	1,751	22
Allen	12	1,563	12	12	1,644	19
Ascension	13	1,718	17	9	3,599	53
Assumption	6	2,874	47	6	3,079	50
Avoyelles	18	2,106	31	16	2,235	39
Beauregard	7	2,530	42	7	2,690	45
Bienville	10	1,909	26	5	2,919	47
Bossier	10	3,696	56	22	3,074	49
Caddo	242	722	2	387	643	2
Calcasieu	74	1,209	88	119	1,432	14
Caldwell	5	2,042	28	4	1,979	30
Cameron	3	2,078	29	3	2,555	42
Catahoula	2	5,869	61	4	2,609	44
Claiborne	17	1,474	11	12	1,208	9
Concordia	6	2,391	39	10	2,352	40
DeSoto	11	2,234	35	5	4,646	60
E. Baton Rouge	183	855	3	316	874	4
E. Carroll	4	4,074	58	6	2,144	34
E. Feliciana	13	1,468	10	16	1,285	11
Evangeline	10	3,190	52	14	2,206	38

(Continued)

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[4] Louisiana State Board of Medical Examiners, Official List (1967). The data obtained from the official list of the Louisiana State Board of Medical Examiners represent all active physicians residing in Louisiana. This source was utilized in Table 1. The American Medical Association Directory was the source of data for physician specialties listed in Table 2. This table does not include federal physicians, and substantial discrepencies in the total number of physicians are noted in Bossier, Jefferson, Orleans and Vernon parishes. The discrepencies found in Jefferson and Orleans parishes are due, in part, to inappropriate inclusion of some Jefferson Parish physicians in the total for Orleans Parish. The Board of Medical Examiners lists 1,646 physicians in Orleans Parish and 304 physicians in Jefferson Parish, while the American Medical Association Directory shows 1,796 and 188 respectively.

[5] Distribution of Physicians, Hospitals, and Hospital Beds in the U.S. 1967. Chicago, American Medical Association (1968).

TABLE 1.—(Continued)

	1950			1967		
		Persons per Dr.			Persons per Dr.	
Parish	No. of doctors	Ratio	Rank	No. of doctors	Ratio	Rank
Franklin	16	1,839	21	8	2,846	46
Grant	4	3,555	55	3	4,079	55
Iberia	23	1,751	18	40	1,520	15
Iberville	14	1,903	24	17	1,886	26
Jackson	9	1,713	16	9	1,749	21
Jefferson	34	3,020	49	304	904	7
Jefferson Davis	15	1,757	19	16	1,976	29
Lafayette	49	1,162	7	123	853	3
Lafourche	22	1,896	23	43	1,606	17
LaSalle	11	1,154	6	8	1,570	16
Lincoln	16	1,589	14	22	1,364	12
Livingston	7	2,828	45	9	3,565	52
Madison	8	2,181	33	4	3,805	54
Morehouse	16	2,004	27	17	1,966	28
Natchitoches	18	2,097	30	15	2,187	36
Orleans	1,312	432	1	1,646	402	1
Ouachita	79	940	5	113	1,057	8
Plaquemines	6	2,371	38	5	5,704	61
Pointe Coupee	7	3,117	51	7	2,972	48
Rapides	98	920	4	138	892	6
Red River	5	2,418	41	4	2,120	33
Richland	14	1,904	25	11	1,895	27
Sabine	9	2,315	37	12	1,371	13
St. Bernard	1	11,089	62	11	4,130	56
St. Charles	6	2,216	34	11	2,461	41
St. Helena	2	4,499	59	1	9,172	64
St. James	5	3,070	50	8	2,602	43
St. John the Baptist	5	2,968	48	5	4,199	57
St. Landry	30	2,612	43	50	1,632	18
St. Martin	8	3,314	54	6	6,655	63
St. Mary	16	2,238	36	33	1,795	24
St. Tammany	20	1,344	9	60	889	5
Tangipahoa	33	1,608	15	29	2,157	35
Tensas	5	2,630	44	3	3,413	51
Terrebonne	18	2,396	40	42	1,780	23
Union	10	1,909	26	8	1,995	31
Vermilion	17	2,169	32	24	1,646	20
Vernon	9	2,106	31	13	1,271	13
Washington	21	1,822	20	25	1,836	25
Webster	19	1,875	22	20	2,038	32
W. Baton Rouge	3	3,854	57	4	4,328	58
W. Carroll	6	2,840	46	2	5,800	62
W. Feliciana	2	5,021	60	3	4,593	59
Winn	5	3,217	53	7	2,198	37
Louisiana	2,709	985		3,941	913	

*Louisiana State Board of Medical Examiners Official List (1967) and Homer L. Hitt, *The Availability of Medical Personnel In Rural Louisiana*, Louisiana State University and Agricultural and Mechanical College, Agricultural Experiment Station, Bulletin No. 459 (1951).

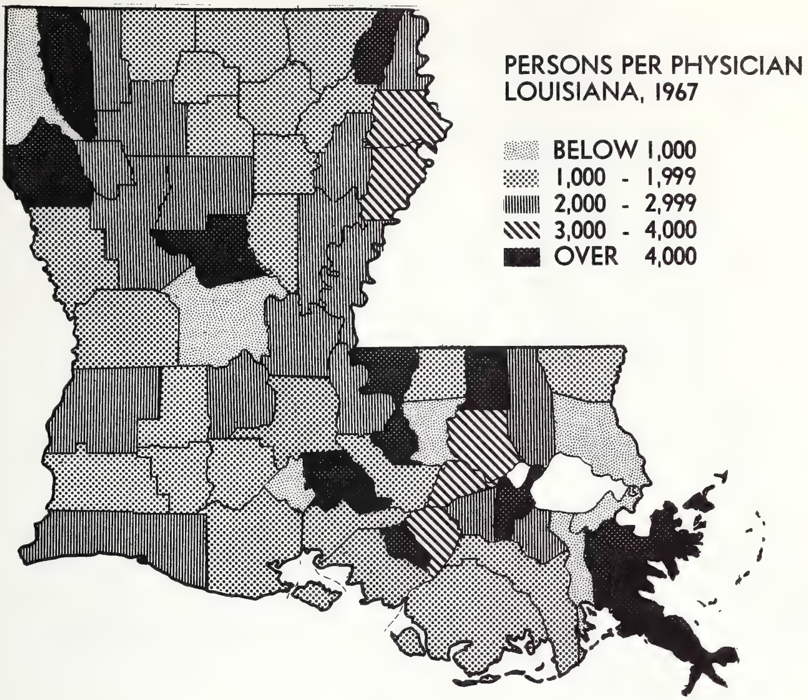

FIGURE 1.—Persons per physician, Louisiana, 1967.

At the most disadvantaged extreme, six parishes had more than 4,500 persons per physician. These were West Feliciana, DeSoto, Plaquemines, West Carroll, St. Martin, and St. Helena. However, since three of these border on parishes containing large urban centers, they can be construed to be partially dependent on the latter for service. Only St. Helena, West Feliciana, and West Carroll parishes appear relatively isolated.

When a distinction is made between completely rural parishes and parishes with urban centers of over 25,000 persons, interesting variations in patterns are noted. The 13 totally rural parishes, taken collectively, had a persons-per-physician ratio of 2,773. It is of note that three of these parishes, East Feliciana, LaSalle and Caldwell, had ratios of less than 2,000. Of the remaining rural parishes, three had ratios between 2,000 and 3,000, but seven had ratios above 3,000.

The nine parishes with urban centers of over 25,000 persons had a total of 3,170 physicians. The persons-per-physician ratio for these parishes was 545. This ratio compares favorably with the 1967 national persons-per-physician ratio of 639. It is significant that the physicians in these nine urban parishes comprised more than 75 per cent of all the physicians in the state.

The above discussion of the distribution of physicians does not give a complete picture of availability. Most physicians practice to some degree as specialists and thus the types of patients and illnesses they treat are limited. The American Medical Association lists 35 specialties. Thirty-three of these were represented among physicians practicing in Louisiana in 1967 (Table 2). The specialties of general surgery, internal medicine, pediatrics, obstetrics and gynecology, and psychiatry comprised approximately 60 per cent of the state total for specialists.[6] Therapeutic radiology and pediatric allergy were not listed by any Louisiana physician as a primary specialty. In addition, three specialties, pediatric cardiology, child psychiatry, and diagnostic roentgenology, were listed as the primary specialty of only one physician each.

The statewide total of physicians listing primary specialties other than general practice was 3,050. Approximately 85 per cent of these practitioners resided in the nine most urban parishes. Less than 1 per cent were located in the 13 totally rural parishes of the state. Orleans Parish alone accounted for over 50 per cent of all primary specialties. The parishes of Caddo, East Baton Rouge and Rapides, collectively, accounted for more than 20 per cent of all specialists.

The data reported above make it clear that Louisiana needs additional medical doctors. They also indicate that persons residing in major urban areas of the state have greater access to medical doctors than those residing in rural areas. This situation is even more marked in regard to specialists. The implications of these findings have their relevance in planning programs for the future.

Availability of Dentists

In 1967, there were 1,376 dentists in Louisiana certified by the State Board of Dentistry (Table 3 and Fig. 2). The ratio of persons per dentist was 2,615. By contrast, there were only 976 certified dentists in the state in 1948. However, the persons-per-dentist ratio of 2,667 for that year indicates that the rate of increase for dentists has barely equaled the rate of growth for the state population in the last two decades. The national ratio of persons per dentist in 1967 was 1,758. The state ratio of 2,615 was 37 per cent above the national average. Orleans, with a ratio of 1,624, was the only parish characterized by a persons-per-dentist ratio below the national average. Only six other parishes had a sufficient number of dentists to fall below the state ratio of persons per dentist. These were Claiborne, Caddo, East Baton Rouge, Jefferson Davis, LaSalle, and Jefferson. In at least one of these parishes, LaSalle, the number of dentists is exaggerated by the presence of several retirees.[7]

Five parishes—Tensas, St. John the Baptist, St. Bernard, West Carroll and East Feliciana—had a persons-per-dentist ratio of over 10,000. No dentists were located in two parishes: Cameron and St. Helena. Such findings suggest a great unmet dental care need.

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[6] The American Medical Association Directory lists primary and secondary specialties. Only primary specialties were utilized in this report.

[7] Verified by personal contact with parish officials.

TABLE 2.—Specialties for Physicians, by Parish, 1967

Specialty	Acadia	Allen	Ascension	Assumption	Avoyelles	Beauregard	Bienville	Bossier	Caddo	Calcasieu	Caldwell	Cameron	Catahoula	Claiborne	Concordia	DeSoto	E. Baton Rouge	E. Carroll	E. Feliciana	Evangeline	Franklin	Grant
General Practice	15	9	7	5	16	5	5	5	51	34	4	3	3	11	6	5	70	6	5	10	10	3
Administrative Medicine	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	3	–				
Allergy	–	–	–	–	–	–	–	–	1	1	–	–	–	–	–	–	1	–				
Anesthesiology	–	–	–	–	–	–	–	1	10	4	–	–	–	–	–	–	12	–	–	–	–	–
Aviation Medicine	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Cardiovascular Disease	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	2	–	–	–	–	–
Child Psychiatry	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Colon & Rectal Surgery	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	1	–	–	–	–	–
Dermatology	–	–	–	–	–	–	–	–	4	2	–	–	–	–	–	–	6	–	–	–	–	–
Diagonostic Roentgenology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Forensic Pathology	–	–	–	–	–	1	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Gastroenterology	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	– 1	–	–	–	–	–
General Preventive Medicine	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	–	–	–
General Surgery	3	–	–	–	–	–	–	1	43	14	–	–	–	1	2	–	27	–	1	2	–	–
Internal Medicine	1	–	–	1	–	–	–	1	40	8	–	–	–	–	–	–	36	–	2	1	–	–
Neurological Surgery	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	3	–	–	–	–	–
Neurology	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	1	–	–	–	–	–
Obstetrics & Gynecology	5	1	–	–	–	–	–	2	24	13	–	–	–	–	–	–	30	–	–	–	–	–
Occupational Medicine	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	5	–	–	–	–	–
Ophthalmology	1	–	–	–	–	–	–	–	21	4	–	–	–	–	–	–	13	–	–	–	–	–
Orthopedic Surgery	–	–	–	–	–	–	–	–	22	6	–	–	–	–	–	–	13	–	–	–	–	–
Otolaryngology	1	1	1	–	–	–	–	–	13	2	–	–	–	–	–	–	11	–	–	–	–	–
Pathology	–	–	–	–	–	–	–	–	9	4	–	–	–	–	–	–	8	–	–	–	–	–
Pediatrics	2	1	–	–	–	–	–	3	25	11	–	–	–	–	1	–	28	–	–	1	–	–
Pediatric Allergy	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pediatric Cardiology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Physical Medicine & Rehabilitation	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–
Plastic Surgery	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	1	–	–	–	–	–
Psychiatry	–	–	–	–	–	–	–	–	12	2	–	–	–	–	–	–	12	–	7	–	–	–
Public Health	–	–	–	–	–	–	–	1	1	1	–	–	1	–	–	–	1	–	–	–	–	–
Pulmonary Diseases	–	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	2	–	–	–	–	–
Radiology	1	–	–	–	–	–	–	–	17	7	–	–	–	–	–	–	10	–	–	–	–	–
Therapeutic Radiology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thoracic Surgery	–	–	–	–	–	–	–	–	3	–	–	–	–	–	–	–	4	–	–	–	–	–
Urology	–	–	–	–	–	–	–	–	14	2	–	–	–	–	–	–	7	–	–	–	–	–

(Continued)

TABLE 2.—(Continued)

Specialty	Iberia	Iberville	Jackson	Jefferson	Jeff. Davis	Lafayette	LaFourche	LaSalle	Lincoln	Livingston	Madison	Morehouse	Natchitoches	Orleans	Ouachita	Plaquemines	Pointe Coupee	Rapides	Red River	Richland	Sabine	St. Bernard
General Practice	25	13	7	37	13	44	21	6	6	3	4	17	10	158	30	5	6	25	3	9	12	7
Administrative Medicine	–	–	1	2	–	2	–	–	–	–	–	–	–	13	–	–	–	2	–	–	–	–
Allergy	–	–	–	–	–	1	–	–	–	1	–	–	–	4	1	–	–	1	–	–	–	–
Anesthesiology	–	–	–	8	–	4	–	–	1	–	–	–	–	41	6	–	–	5	–	–	–	–
Aviation Medicine	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Cardiovascular Disease	–	–	–	–	1	–	–	–	–	–	–	–	–	7	–	–	–	–	–	–	–	–
Child Psychiatry	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Colon & Rectal Surgery	–	–	–	–	–	–	–	–	–	–	–	–	–	9	–	–	–	–	–	–	–	–
Dermatology	–	–	–	7	–	3	–	–	–	–	–	–	–	32	2	–	–	1	–	–	–	–
Diagonostic Roentgenology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Forensic Pathology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Gastroenterology	–	–	–	–	–	–	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	–
General Preventive Medicine	–	–	–	–	–	–	–	–	–	–	–	–	–	8	–	–	–	1	–	–	–	–
General Surgery	3	2	–	17	1	12	6	1	4	2	–	1	1	190	13	–	–	18	–	–	–	–
Internal Medicine	3	–	–	27	–	8	1	1	3	–	–	–	1	268	9	–	–	12	–	–	–	1
Neurological Surgery	–	–	–	2	–	–	–	–	–	–	–	–	–	17	1	–	–	–	–	–	–	–
Neurology	–	–	–	1	–	–	–	–	–	–	–	–	–	18	–	–	–	–	–	–	–	–
Obstetrics & Gynecology	3	–	–	22	–	6	5	–	2	–	–	–	–	147	9	–	–	8	–	1	–	–
Occupational Medicine	–	–	–	–	–	–	–	–	–	–	–	–	–	11	–	–	–	–	–	–	–	–
Ophthalmology	1	–	–	9	–	8	1	–	1	–	–	–	–	82	4	–	–	4	–	–	–	1
Orthopedic Surgery	–	–	–	2	–	5	–	–	–	–	–	–	–	73	6	–	–	5	–	–	–	–
Otolaryngology	1	–	–	6	1	3	–	–	–	–	–	–	–	61	4	–	–	3	–	–	–	1
Pathology	–	–	–	2	–	3	1	–	1	–	–	–	–	55	5	–	–	3	–	–	–	1
Pediatrics	2	–	–	19	–	9	5	–	2	–	–	–	1	121	10	–	–	7	–	1	–	1
Pediatric Allergy	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Pediatric Cardiology	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Physical Medicine & Rehabilitation	–	–	–	–	–	–	–	–	–	–	–	–	1	3	–	–	–	–	–	–	–	–
Plastic Surgery	–	–	–	–	–	–	–	–	–	–	–	–	–	12	1	–	–	1	–	–	–	–
Psychiatry	–	2	–	6	–	4	–	–	–	1	–	–	1	125	4	–	–	14	–	–	–	–
Public Health	–	–	–	1	–	–	–	–	–	–	–	–	–	9	1	–	–	–	–	–	–	–
Pulmonary Diseases	–	–	–	–	–	–	–	–	–	–	–	–	–	3	–	–	–	1	–	–	–	–
Radiology	2	–	–	7	–	5	–	–	1	–	–	–	–	63	7	–	–	3	–	–	1	–
Therapeutic Radiology	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Thoracic Surgery	–	–	–	–	–	1	–	–	–	–	–	–	–	13	–	–	–	–	–	–	–	–
Urology	1	–	–	4	–	6	–	–	–	–	–	–	–	56	2	–	–	6	–	–	–	–

(Continued)

TABLE 2.—(Continued)

Specialty	St. Charles	St. Helena	St. James	St. John	St. Landry	St. Martin	St. Mary	St. Tammany	Tangipahoa	Tensas	Terrebonne	Union	Vermilion	Vernon	Washington	Webster	W. Baton Rouge	W. Carroll	W. Feliciana	Winn	Total
General Practice	10	1	10	4	28	6	18	14	15	3	20	7	14	6	12	13	3	2	3	6	944
Administrative Medicine	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	—	27
Allergy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11
Anesthesiology	—	—	—	—	1	—	1	1	1	—	—	—	1	—	1	1	—	—	—	—	99
Aviation Medicine	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Cardiovascular Disease	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13
Child Psychiatry	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Colon & Rectal Surgery	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	14
Dermatology	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	57
Diagonostic Roentgenology	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Forensic Pathology	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
Gastroenterology	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7
General Preventive Medicine	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11
General Surgery	1	—	1	—	3	—	3	1	2	—	4	—	2	—	5	3	—	—	—	1	391
Internal Medicine	—	—	—	—	3	—	—	5	2	—	2	—	—	—	1	1	—	—	—	—	438
Neurological Surgery	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	26
Neurology	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	23
Obstetrics & Gynecology	—	—	—	—	5	—	2	5	5	—	4	—	3	—	3	1	—	—	—	—	306
Occupational Medicine	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18
Ophthalmology	—	—	—	—	1	—	—	—	—	—	2	—	2	—	2	—	—	—	—	—	157
Orthopedic Surgery	—	—	—	1	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	135
Otolaryngology	—	—	—	—	3	—	—	1	—	—	2	—	—	—	—	—	—	—	—	—	115
Pathology	—	—	—	—	1	—	1	2	—	—	1	—	—	—	—	—	—	—	—	—	97
Pediatrics	1	—	—	—	3	—	2	4	2	—	3	—	—	—	1	2	—	—	—	—	269
Pediatric Allergy	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
Pediatric Cardiology	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Physical Medicine & Rehabilitation	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	6
Plastic Surgery	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	18
Psychiatry	—	—	—	—	—	—	—	13	—	—	—	—	—	—	—	—	—	—	—	—	203
Public Health	—	—	—	—	1	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	19
Pulmonary Diseases	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8
Radiology	—	—	—	—	2	—	2	1	1	—	2	—	—	—	1	—	—	—	—	1	134
Therapeutic Radiology	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0
Thoracic Surgery	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	21
Urology	—	—	—	—	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	100

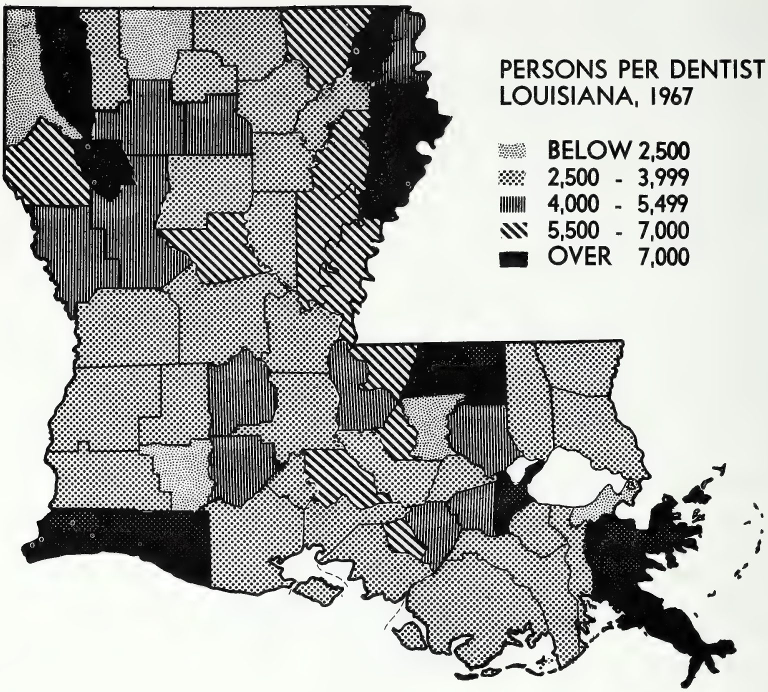

FIGURE 2.—Persons per dentist, Louisiana, 1967.

TABLE 3.—Number of Dentists and Persons per Dentist, by Parish, 1948 and 1967*

	1948			1967		
		Persons per D.D.S.			Persons per D.D.S.	
Parish	No. of Dentists	Ratio	Rank	No. of Dentists	Ratio	Rank
Acadia	10	4,687	38	11	4,617	37
Allen	4	4,628	37	7	2,818	12
Ascension	5	4,422	33	10	3,239	22
Assumption	6	2,917	10	4	4,619	38
Avoyelles	14	2,727	7	10	3,577	28
Beauregard	3	5,713	46	5	3,766	30
Bienville	5	4,011	24	3	4,866	39
Bossier	7	5,171	43	7	9,660	57
Caddo	87	1,952	2	137	1,817	3
Calcasieu	30	2,763	8	62	2,749	10
Caldwell	3	3,526	19	2	3,958	33
Cameron	1	6,429	50	0	——	63
Catahoula	3	4,105	26	2	5,218	42
Claiborne	10	2,602	6	8	1,811	2
Concordia	3	4,797	40	4	5,879	51
DeSoto	7	3,717	21	4	5,808	50

(Continued)

TABLE 3.—(Continued)

	1948			1967		
		Persons per D.D.S.			Persons per D.D.S.	
Parish	No. of Dentists	Ratio	Rank	No. of Dentists	Ratio	Rank
E. Baton Rouge	69	2,071	3	134	2,062	4
E. Carroll	2	8,421	54	3	4,288	35
E. Feliciana	3	6,292	49	1	20,556	62
Evangeline	7	4,512	35	7	4,412	36
Franklin	4	7,498	52	4	5,691	47
Grant	1	14,561	59	2	6,119	32
Iberia	14	2,833	9	20	3,039	17
Iberville	6	4,477	34	10	3,207	21
Jackson	2	7,946	53	3	5,248	43
Jefferson	9	10,249	56	108	2,546	7
Jefferson Davis	8	3,241	15	13	2,432	5
Lafayette	23	2,363	4	37	2,835	13
Lafourche	13	3,160	12	24	2,878	14
LaSalle	3	4,109	27	5	2,511	6
Lincoln	6	4,217	29	9	3,335	25
Livingston	1	19,397	60	6	5,348	44
Madison	2	8,822	55	2	7,611	55
Morehouse	6	5,194	44	6	5,572	46
Natchitoches	9	4,266	30	8	4,101	34
Orleans	391	1,414	1	407	1,629	1
Ouachita	29	2,457	5	39	3,062	18
Plaquemines	—	——	64	4	7,131	54
Pointe Coupee	6	3,710	20	4	5,200	40
Rapides	29	2,992	11	47	2,619	8
Red River	1	12,850	58	1	8,478	56
Richland	7	3,870	22	6	3,475	26
Sabine	1	21,388	61	3	5,485	45
St. Bernard	—	——	63	4	11,357	60
St. Charles	3	4,367	31	7	3,867	31
St. Helena	—	——	62	——	——	64
St. James	4	3,900	23	4	5,203	41
St. John the Baptist	3	4,942	42	2	10,499	59
St. Landry	16	4,812	41	27	3,023	16
St. Martin	5	5,291	45	7	5,705	48
St. Mary	11	3,176	13	17	3,484	27
St. Tammany	6	4,372	32	20	2,667	9
Tangipahoa	15	3,436	17	17	3,680	29
Tensas	3	4,570	36	1	10,238	58
Terrebonne	12	3,473	18	19	3,935	32
Union	3	6,487	51	5	3,192	20
Vermilion	11	3,367	16	12	3,291	24
Vernon	4	4,748	39	6	2,754	11
Washington	9	4,167	28	14	3,278	23
Webster	11	3,203	14	14	2,911	15
W. Baton Rouge	2	5,751	47	3	5,771	49
W. Carroll	3	5,828	48	1	11,601	61
W. Feliciana	1	10,378	57	2	6,890	53
Winn	4	4,063	25	5	3,077	19
Louisiana	976	2,670	—	1,376	2,615	—

**Official List Dentists,* Louisiana State Board of Dentistry (1965-1967).

The 13 totally rural parishes had an average persons-per-dentist ratio of 7,542. This ratio was over three times the persons-per-dentist ratio of 2,059 for the nine urban parishes with centers of 25,000 or over. Only one of the urban parishes, Bossier, ranked as high as 20th among the 64 parishes, while eight of the 13 totally rural parishes ranked between 50th and 64th.

Again, the data collected show an important health care need in Louisiana. In fact, the need for dentists appears more critical in some areas than the need for physicians. It is clear that a direct relationship exists between urbanization and adequate numbers of dental personnel.

Availability of Registered Nurses

The number of registered nurses in Louisiana was 7,450 in 1967 (Table 4 and Fig. 3). Approximately 90 per cent of these were classified as "active" by the Louisiana State Board of Nurse Examiners.[8] The state ratio of persons per registered nurse was 483. In 1949, there were 6,060 registered nurses in the state. This represented a persons-per-registered nurse ratio of 435. Thus, the increase in total number of registered nurses during this 18-year period was not sufficient to counter the effects of a growing state population.

TABLE 4.—Number of Registered Nurses and Persons per Registered Nurse, by Parish, 1949 and 1967*

	1949			1967		
		Persons per R.N.			Persons per R.N.	
Parish	No. of R.N.	Ratio	Rank	No. of R.N.	Ratio	Rank
Acadia	34	1,380	38	47	1,080	36
Allen	16	1,164	27	16	12,327	64
Ascension	19	1,170	28	18	1,799	54
Assumption	19	914	19	9	2,053	57
Avoyelles	29	1,312	32	32	1,118	40
Beauregard	11	1,584	43	27	697	22
Bienville	20	979	22	5	2,919	59
Bossier	48	762	16	71	952	32
Caddo	733	235	2	813	306	2
Calcasieu	199	433	7	290	588	17
Caldwell	13	800	17	18	440	8
Cameron	1	6,332	61	7	1,095	38
Catahoula	2	6,013	59	7	1,491	50
Claiborne	18	1,419	39	26	557	16
Concordia	7	2,053	53	12	1,960	56
DeSoto	16	1,581	42	19	1,223	43
E. Baton Rouge	535	280	4	775	357	5
E. Carroll	11	1,506	41	6	2,150	58
E. Feliciana	14	1,356	36	43	478	12
Evangeline	19	1,670	44	35	882	28

(Continued)

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[8] Officials of the Louisiana State Nurses Association estimated that approximately 1,000 of the 7,450 registered nurses were not actively employed.

TABLE 4.—(Continued)

Parish	1949			1967		
	No. of R.N.	Persons per R.N. Ratio	Persons per R.N. Rank	No. of R.N.	Persons per R.N. Ratio	Persons per R.N. Rank
Franklin	22	1,350	35	18	1,265	45
Grant	14	1,028	23	2	6,119	63
Iberia	34	1,176	29	64	950	31
Iberville	43	622	10	42	764	25
Jackson	8	1,957	52	19	829	26
Jefferson	140	696	14	499	551	14
Jefferson Davis	14	1,867	48	29	1,090	37
Lafayette	88	632	11	237	443	10
Lafourche	48	862	18	112	617	18
LaSalle	12	1,043	24	8	1,570	52
Lincoln	54	470	8	68	441	9
Livingston	9	2,178	55	36	891	29
Madison	9	1,949	51	9	1,691	53
Morehouse	23	1,374	37	49	682	21
Natchitoches	20	1,903	49	49	670	20
Orleans	2,568	218	1	2,243	295	1
Ouachita	250	291	5	285	419	6
Plaquemines	12	1,170	28	24	1,188	42
Pointe Coupee	12	1,837	47	14	1,486	49
Rapides	332	266	3	386	319	3
Red River	2	6,236	60	6	1,413	48
Richland	15	1,791	46	23	906	30
Sabine	16	1,320	33	19	866	27
St. Bernard	15	714	15	29	1,667	51
St. Charles	11	1,200	30	38	712	23
St. Helena	—	——	62	7	1,310	47
St. James	9	1,719	45	20	1,041	34
St. John the Baptist	10	1,483	40	11	1,909	55
St. Landry	62	1,253	31	76	1,074	35
St. Martin	10	2,647	57	9	3,659	61
St. Mary	87	956	21	80	740	24
St. Tammany	24	1,107	25	116	460	11
Tangipahoa	57	918	20	120	521	13
Tensas	10	1,343	34	9	1,138	41
Terrebonne	64	663	12	134	558	16
Union	10	1,927	50	13	1,228	44
Vermilion	19	1,949	51	40	987	33
Vernon	17	1,116	26	30	342	4
Washington	93	407	6	108	425	7
Webster	69	513	9	62	657	19
W. Baton Rouge	17	678	13	4	4,328	62
W. Carroll	8	2,158	54	9	1,289	46
W. Feliciana	2	5,105	58	4	3,445	60
Winn	7	2,310	56	14	1,099	39
Louisiana	6,060	435		7,450	483	

*Official List of the Louisiana State Board of Nurse Examiners (1967).

In 1967, there were 299 persons per registered nurse in the nation. This ratio was approximately 40 per cent lower than the Louisiana ratio and indicated the state's unenviable position. In 1940, the national ratio of persons per registered nurse was 370. It is of note that the national ratio decreased substantially, while the state ratio increased.

Within the state, the parishes of Orleans, Caddo, Rapides, Vernon, and East Baton Rouge had less than 400 persons per registered nurse in 1967. Of these five parishes, only Orleans had a ratio which fell below the national average.

Five parishes in the state were found to have more than 3,000 persons per registered nurse. West Feliciana, St. Martin, West Baton Rouge, Grant, and Allen parishes fell within this group. It should be noted that, with the exception of Grant, each of these parishes is contiguous to a parish having a large urban center.

A comparison of the 13 totally rural parishes with the nine parishes containing urban centers of over 25,000 again revealed that the rural parishes were relatively disadvantaged. In all of the 13 rural parishes there were only 158 registered nurses. The ratio of persons per registered nurse was 1,193. Eleven of the 13 rural parishes showed over 1,000 persons per registered nurse. In the nine urban parishes the number of

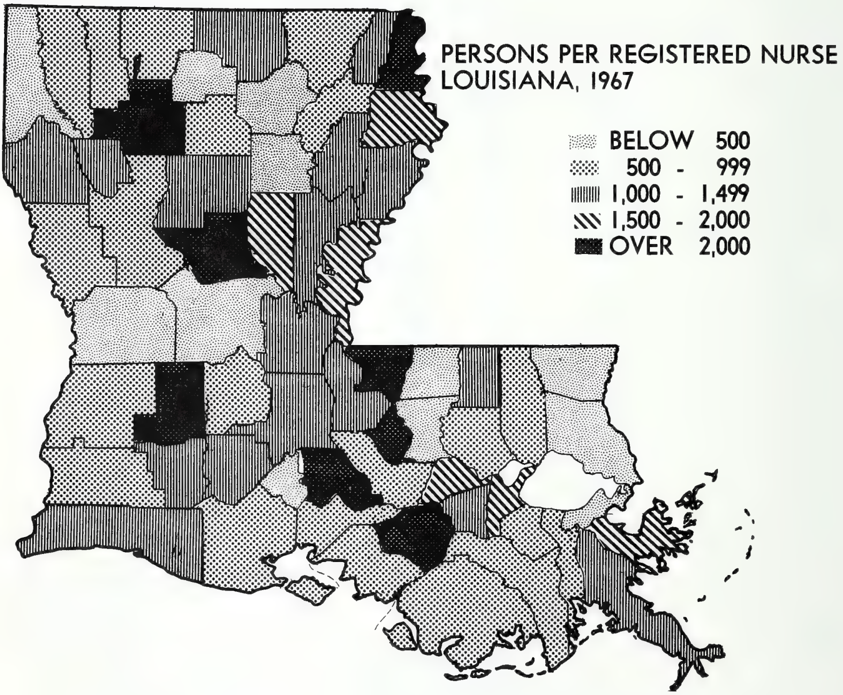

FIGURE 3.—Persons per registered nurse, Louisiana, 1967.

persons per registered nurse was only 355. This was less than one-third the number of persons served by one nurse in the rural parishes. Six of the nine urban parishes ranked within the 10 parishes having the most favorable population-nurse ratios.

These findings highlight a growing problem. This is the fact that professional nurses are in very short supply everywhere. The fact that the state ratio is less favorable than the national ratio emphasizes the need for a serious study of the nursing shortage.

Availability of Licensed Practical Nurses

In Louisiana the licensing of practical nurses is relatively new. The program began in 1949. The rapid development of this paramedical

TABLE 5.—Number of Licensed Practical Nurses and Persons per Licensed Practical Nurse, by Parish, 1967*

		Persons per L.P.N.	
Parish	No. of L.P.N.	Ratio	Rank
Acadia	65	781	24
Allen	16	1,233	43
Ascension	19	1,705	49
Assumption	9	2,053	54
Avoyelles	25	1,431	46
Beauregard	26	724	17
Bienville	18	811	27
Bossier	88	768	22
Caddo	684	364	3
Calcasieu	353	483	9
Caldwell	29	272	1
Cameron	3	2,555	56
Catahoula	12	870	34
Claiborne	20	725	18
Concordia	8	2,940	58
DeSoto	32	726	19
E. Baton Rouge	499	554	11
E. Carroll	4	3,216	60
E. Feliciana	22	934	37
Evangeline	52	594	14
Franklin	24	949	38
Grant	20	612	16
Iberia	72	844	31
Iberville	40	802	25
Jackson	27	583	13
Jefferson	331	830	29
Jefferson Davis	39	810	26
Lafayette	175	599	15
Lafourche	56	1,234	44
LaSalle	12	1,046	40
Lincoln	54	556	12
Livingston	39	823	28
Madison	4	3,805	61
Morehouse	63	531	10
Natchitoches	37	886	35
Orleans	1,437	460	8
Ouachita	281	425	4
Plaquemines	10	2,852	57
Pointe Coupee	16	1,300	45
Rapides	286	430	5
Red River	8	1,060	41
Richland	24	868	33
Sabine	18	914	36
St. Bernard	41	1,108	42
St. Charles	15	1,804	51
St. Helena	2	4,586	62
St. James	7	2,973	59
St. John the Baptist	3	6,997	63
St. Landry	189	432	6
St. Martin	20	1,647	48
St. Mary	33	1,795	50
St. Tammany	70	762	21
Tangipahoa	72	869	32
Tensas	5	2,048	55
Terrebonne	38	1,968	52
Union	10	1,596	47
Vermilion	54	731	20
Vernon	36	459	7
Washington	168	273	2
Webster	49	832	30
W. Baton Rouge	17	1,018	39
W. Carroll	6	1,934	53
W. Feliciana	1	13,780	64
Winn	20	769	23
Louisiana	5,913	609	

*Official Roster of the Louisiana State Board of Practical Nurse Examiners (1967).

specialty within recent years has been, in part, a consequence of the chronic unmet need for registered nurses.

In 1967, there were 5,913 licensed practical nurses registered in the state, with a ratio of persons per licensed practical nurse of 609 (Table 5). In the United States, in 1967, there were approximately 615 persons per licensed practical nurse. It is interesting that licensed practical nurses were in relatively greater supply in Louisiana than in the nation. This appears to be one of the only medically-related occupations in the state displaying a more favorable ratio than that found at the national level.

Nine parishes in Louisiana had less than 500 persons per licensed practical nurse. These included Caldwell, Washington, Caddo, Ouachita, Rapides, St. Landry, Vernon, Orleans, and Calcasieu. At the other extreme, five parishes had more than 3,000 persons for each licensed practical nurse. These were East Carroll, Madison, St. Helena, St. John the Baptist, and West Feliciana. Only one licensed practical nurse reported living in West Feliciana Parish.

The distribution of licensed practical nurses in totally rural parishes and in parishes having large urban centers did not follow the patterns of medical personnel mentioned previously, although some similarities were noted. While the ratios were more favorable in urban than in rural parishes, the differences were not as extreme. The 13 totally rural parishes had a ratio of persons per licensed practical nurse of 1,109, which was in contrast to a ratio of 473 for the nine urban parishes. Orleans Parish, the largest urban area in the state, consistently ranked best in ratios of persons per physician, dentist, and registered nurse. However, in the case of licensed practical nurses, Orleans Parish dropped to eighth position in the state, while a rural parish, Caldwell, had the lowest ratio of persons per licensed practical nurse.

Louisiana, in 1967, compared favorably with the national ratio of licensed practical nurses. This was probably accounted for by the presence of several active training programs spread over the state. However, a thorough investigation is needed to determine why some inequities in distribution existed.

Availability of Medical Technologists

In 1967, there were 1,077 registered medical technologists in Louisiana (Table 6). The ratio of persons per medical technologist in the state was 3,342.

Almost all medical technologists work in hospitals, clinics, or other diagnostic centers. Because of this, it was expected that the distribution of medical technologists would not be as diffused as the distribution of most other medical specialties. This was in fact evidenced in the wide range found among parishes in ratios of persons per medical technologist. Vernon Parish, for example, had a ratio of persons per medical technologist of 1,650. This was accounted for by the presence of Fort Polk's medical facilities. By comparison, Webster Parish had only one medical technologist for a population of over 40,000 persons. This can probably be explained by the proximity of Webster Parish to Shreveport. Parishes with persons-per-medical technologist ratios of less than 2,500 were Vernon, Lafayette, Orleans, Livingston, Jefferson, Caddo, and East Baton Rouge.

Nine parishes in Louisiana had no registered medical technologists in residence and it should be noted that, of these, Plaquemines, DeSoto, Franklin, Jackson, West Feliciana, St. Helena, and Caldwell had hospital facilities of some type.

The 13 totally rural parishes, altogether, had only 19 medical technologists in residence, and five of these parishes had none. The ratio of persons per medical technologist in the rural parishes was 9,922. This ratio compared unfavorably with the ratio of 2,400 for the nine urban parishes. However, as mentioned previously, medical technologists are primarily hospital or clinic personnel and urban parishes obviously would contain more hospitals and clinics than rural parishes.

TABLE 6.—Number of Medical Technologists and Persons per Medical Technologist, by Parish, 1967*

	No. of	Persons per Med. Tech.			No. of	Persons per Med. Tech.	
Parish	M.T.	Ratio	Rank	Parish	M.T.	Ratio	Rank
Acadia	4	12,696	47	Madison	3	5,074	17
Allen	2	9,862	39	Morehouse	5	6,686	29
Ascension	3	10,797	44	Natchitoches	9	3,646	11
Assumption	2	9,238	38	Orleans	331	1,997	3
Avoyelles	5	7,153	34	Ouachita	41	2,913	9
Beauregard	3	6,277	26	Plaquemines	—	—	64
Bienville	1	14,597	49	Pointe Coupee	2	10,410	41
Bossier	10	6,762	30	Rapides	45	2,735	8
Caddo	112	2,222	6	Red River	—	—	58
Calcasieu	37	4,606	14	Richland	3	6,949	33
Caldwell	—	—	55	Sabine	3	5,485	20
Cameron	1	7,666	35	St. Bernard	8	5,679	21
Catahoula	1	10,436	42	St. Charles	3	9,022	37
Claiborne	3	4,831	15	St. Helena	—	—	57
Concordia	2	11,759	45	St. James	4	5,203	19
DeSoto	—	—	63	St. John the Baptist	2	10,499	43
E. Baton Rouge	112	2,467	7	St. Landry	12	6,801	32
E. Carroll	1	12,863	48	St. Martin	2	19,966	52
E. Feliciana	1	20,555	53	St. Mary	5	11,865	46
Evangeline	3	10,294	40	St. Tammany	8	6,668	28
Franklin	—	—	62	Tangipahoa	10	6,255	25
Grant	—	—	59	Tensas	2	5,119	18
Iberia	10	6,731	31	Terrebonne	12	6,231	24
Iberville	1	32,070	54	Union	4	3,991	19
Jackson	—	—	61	Vermilion	13	3,038	10
Jefferson	133	2,067	5	Vernon	10	1,652	1
Jefferson Davis	7	4,516	13	Washington	3	15,296	50
Lafayette	53	1,979	2	Webster	1	40,753	55
Lafourche	12	5,756	22	W. Baton Rouge	1	17,312	51
LaSalle	2	6,278	27	W. Carroll	2	5,801	23
Lincoln	6	5,003	16	W. Feliciana	—	—	60
Livingston	4	2,006	4	Winn	2	7,693	36
				Louisiana	1,077	3,342	

*Board of Registry, American Society of Clinical Pathologists (1967).

National and historical data on medical technologists were not available in a form which allowed quick comparisons. The time and resources available did not permit the processing of these data for this report. However, one can infer that there is a need for additional registered medical technologists when it is noted that some hospitals and clinics apparently did not have such personnel.

Availability of Radiologic Technologists

The distribution of radiologic technologists throughout the state followed much the same pattern found for medical personnel previously mentioned. In 1968, there were 798 radiologic technologists in Louisiana (Table 7). One estimate was that about one fourth of these were employed in hospitals.[9] The ratio of persons per radiologic technologist was 4,578.[10]

Parishes with more than one radiologic technologist for each 3,000 persons were Cameron, Evangeline, Jefferson, Caddo, and St. Tammany. Cameron's position as the parish with the most favorable ratio can be accounted for by the relatively low population of the parish. Actually, there were only four radiologic technologists registered in Cameron Parish in 1968.

Seven parishes in the state had no radiologic technologists in residence. These were Red River, West Carroll, West Feliciana, Claiborne, St. John the Baptist, Point Coupee, and Plaquemines. Other parishes showing a marked deficiency in this area, with more than 20,000 persons per radiologic technologist, were East Feliciana, Franklin, Richland, and Webster.

The 13 totally rural parishes in the state, collectively, had only 24 radiologic technologists in residence. This was reflected in a ratio of persons per radiologic technologist of 8,171. Three of the totally rural parishes, Red River, West Carroll, and West Feliciana, were included among the parishes in which no radiologic technologist reported residence.

The ratio of persons per radiologic technologist in parishes with an urban center of 25,000 was, by comparison, much more favorable. There were 490 radiologic technologists in these nine parishes. This number yielded a ratio of 3,751 persons per technologist. Six of the 10 parishes with the most favorable ratios were urban parishes.

Again, no data were readily obtainable for historical comparisons. However, as in the case of medical technologists, it is apparent that an overall shortage exists.

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[9] Health Resources Statistics, U.S. Department of Health, Education, and Welfare (1968).

[10] The American Registry of Radiologic Technologists lists the following three categories of certification: X-ray technology, nuclear medicine technology, and radiation therapy technology. Only seven persons in Louisiana were registered as nuclear medicine technologists and three were certified as radiation therapy technologists.

TABLE 7.—Number of Radiologic Technologists and Persons per Radiologic Technologist, by Parish, 1968*

Parish	No. of R.T.	Persons per R.T. Ratio	Persons per R.T. Rank	Parish	No. of R.T.	Persons per R.T. Ratio	Persons per R.T. Rank
Acadia	9	5,788	19	Madison	1	17,226	51
Allen	2	10,306	37	Morehouse	3	11,660	41
Ascension	7	4,733	14	Natchitoches	5	6,721	22
Assumption	1	17,415	52	Orleans	165	4,005	12
Avoyelles	3	12,709	44	Ouachita	35	3,323	9
Beauregard	2	9,811	26	Plaquemines	—	——	64
Bienville	1	16,365	49	Pointe Coupee	—	——	63
Bossier	22	3,159	6	Rapides	39	3,236	8
Caddo	97	2,585	4	Red River	—	——	58
Calcasieu	35	4,942	17	Richland	1	22,503	55
Caldwell	1	8,501	32	Sabine	2	8,749	34
Cameron	4	2,027	1	St. Bernard	9	5,342	18
Catahoula	1	10,593	38	St. Charles	2	14,638	46
Claiborne	—	——	61	St. Helena	2	4,349	13
Concordia	3	7,276	24	St. James	2	10,786	39
DeSoto	1	24,235	57	St. John the Baptist	—	——	62
E. Baton Rouge	57	4,913	16	St. Landry	7	12,228	42
E. Carroll	2	6,327	21	St. Martin	4	8,077	29
E. Feliciana	1	20,719	53	St. Mary	7	8,434	31
Evangeline	15	2,082	2	St. Tammany	20	2,641	5
Franklin	1	22,983	56	Tangipahoa	4	16,070	48
Grant	3	3,966	11	Tensas	1	11,618	40
Iberia	10	6,180	20	Terrebonne	6	12,592	43
Iberville	4	8,069	28	Union	1	17,160	50
Jackson	2	7,868	26	Vermilion	6	6,796	23
Jefferson	113	2,480	3	Vernon	2	9,115	35
Jefferson Davis	5	7,975	27	Washington	3	15,628	47
Lafayette	30	3,453	10	Webster	2	21,296	54
Lafourche	21	3,277	7	W. Baton Rouge	2	8,294	30
LaSalle	1	13,050	45	W. Carroll	—	——	59
Lincoln	4	7,347	25	W. Feliciana	—	——	60
Livingston	7	4,819	15	Winn	2	8,692	33
				Louisiana	798	4,578	

*The American Registry of Radiologic Technologists (1968).

Availability of Physical Therapists

The distribution of physical therapists throughout the state, as expected, was extremely uneven. In fact, only 117 physical therapists were registered with the Louisiana State Board of Medical Examiners in 1968 and these claimed residence in only 23 of the 64 parishes (Table 8).[11]

Parishes with the most favorable ratio of persons per physical therapist were Orleans, Vermilion, Caddo, and Claiborne. Each of these parishes had less than 20,000 persons for each physical therapist.

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[11] The data reported here includes physical therapists registered nationally and those registered with the state.

TABLE 8.—Number of Physical Therapists and Persons per Physical Therapist, by Parish, 1968*

	No. of	Persons per P.T.			No. of	Persons per P.T.	
Parish	P.T.	Ratio	Rank	Parish	P.T.	Ratio	Rank
Acadia	1	52,082	19	Madison	—	——	39
Allen	—	——	45	Morehouse	—	——	60
Ascension	—	——	58	Natchitoches	1	33,605	13
Assumption	—	——	41	Orleans	55	12,015	1
Avoyelles	—	——	61	Ouachita	5	23,259	6
Beauregard	—	——	44	Plaquemines	—	——	54
Bienville	—	——	36	Pointe Coupee	—	——	48
Bossier	2	34,744	16	Rapides	4	31,549	11
Caddo	15	16,718	5	Red River	—	——	27
Calcasieu	5	34,600	15	Richland	—	——	51
Caldwell	—	——	25	Sabine	—	——	42
Cameron	—	——	24	St. Bernard	—	——	64
Catahoula	—	——	28	St. Charles	—	——	55
Claiborne	1	16,715	4	St. Helena	—	——	26
Concordia	—	——	50	St. James	—	——	49
DeSoto	—	——	53	St. John the Baptist	—	——	47
E. Baton Rouge	4	70,007	22	St. Landry	2	42,799	18
E. Carroll	—	——	31	St. Martin	—	——	57
E. Feliciana	—	——	46	St. Mary	2	29,518	8
Evangeline	—	——	56	St. Tammany	1	52,814	20
Franklin	—	——	52	Tangipahoa	2	32,140	12
Grant	—	——	30	Tensas	—	——	29
Iberia	2	30,899	10	Terrebonne	2	37,778	17
Iberville	2	16,138	3	Union	—	——	38
Jackson	—	——	35	Vermilion	3	13,592	2
Jefferson	2	140,140	23	Vernon	—	——	43
Jefferson Davis	1	29,877	9	Washington	—	——	63
Lafayette	3	34,533	14	Webster	—	——	62
Lafourche	1	68,822	21	W. Baton Rouge	—	——	37
LaSalle	—	——	33	W. Carroll	—	——	32
Lincoln	1	29,389	7	W. Feliciana	—	——	34
Livingston	—	——	59	Winn	—	——	40
				Louisiana	117	31,222	

*Roster, Louisiana Chapter, American Physical Therapy Association (1968).

None of the totally rural parishes included a physical therapist among its inhabitants. By sharp contrast, 95 of the 117 physical therapists in the state resided in nine parishes with a population center of at least 25,000. It is of even more significance that 60 per cent of the 117 physical therapists in the state were located in Orleans and Caddo parishes.

It is difficult to speak of the need of a highly specialized occupation such as that of the physical therapist without basic information relative to optimal persons-to-specialist ratios. Yet one may observe that the relative concentration of physical therapists represents a degree of inaccessability for many needy persons, especially in rural areas of the state. It also seems likely that the number of therapists is inadequate to serve the state population.

Availability of Dietitians

The functions of dietitians are not limited to medically-related institutions. However, nutrition is an integral part of health care, and in this sense dietitians can be classified as paramedical personnel. In 1968, there were 319 members of the American Dietetic Association who reported residence in Louisiana.[12] This represented a persons-per-dietitian ratio of 11,380 (Table 9).

TABLE 9.—Number of Dietitians and Persons per Dietitian, by Parish, 1968*

Parish	No. of Dietitians	Persons per Dietitian	
		Ratio	Rank
Acadia	1	52,082	40
Allen	—	—	53
Ascension	1	33,128	35
Assumption	—	—	63
Avoyelles	2	19,065	27
Beauregard	—	—	52
Bienville	—	—	48
Bossier	2	34,744	37
Caddo	22	12,308	15
Calcasieu	9	19,222	28
Caldwell	—	—	44
Cameron	—	—	43
Catahoula	—	—	45
Claiborne	1	16,715	23
Concordia	—	—	57
DeSoto	—	—	59
E. Baton Rouge	52	5,385	3
E. Carroll	1	12,653	17
E. Feliciana	1	20,719	30
Evangeline	—	—	62
Franklin	1	22,983	32
Grant	2	5,950	5
Iberia	1	61,797	41
Iberville	2	16,138	22
Jackson	2	7,868	8
Jefferson	10	28,028	34
Jefferson Davis	3	9,959	12
Lafayette	19	5,452	4
Lafourche	2	34,411	36
LaSalle	1	13,050	20
Lincoln	10	2,939	1
Livingston	2	16,868	25
Madison	—	—	50
Morehouse	3	11,660	14
Natchitoches	2	16,803	24
Orleans	105	6,294	6
Ouachita	10	11,630	13
Plaquemines	—	—	60
Pointe Coupee	—	—	55
Rapides	17	7,423	7
Red River	1	9,867	11
Richland	—	—	58
Sabine	2	8,799	10
St. Bernard	1	48,080	39
St. Charles	—	—	61
St. Helena	1	8,699	9
St. James	—	—	56
St. John the Baptist	—	—	54
St. Landry	1	85,597	42
St. Martin	—	—	64
St. Mary	3	19,678	29
St. Tammany	4	13,204	21
Tangipahoa	5	12,856	19
Tensas	—	—	46
Terrebonne	6	12,593	16
Union	1	17,160	26
Vermilion	1	40,777	38
Vernon	4	4,558	2
Washington	2	23,442	33
Webster	2	21,296	31
W. Baton Rouge	—	—	49
W. Carroll	1	12,739	18
W. Feliciana	—	—	47
Winn	—	—	51
Louisiana	321	11,380	

*Roster, Louisiana Dietetic Association (1968).

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[12] According to the membership roster of the Louisiana Dietetic Association approximately one-third of these were employed in hospitals.

Parishes with less than 7,000 persons per dietitian were Lincoln, Vernon, East Baton Rouge, Lafayette, Grant, and Orleans. At the other extreme, 22 parishes had no dietitians reporting residence within their bounds, although 21 of these parishes had hospital facilities. It can be presumed that there were food service personnel employed in these parishes who did not qualify for membership in the American Dietetic Association. Five parishes had a persons-per-dietitian ratio ranging from 40,000 to 85,000. These were Vermilion, St. Bernard, Acadia, Iberia, and St. Landry parishes.

There were only eight members of the American Dietetic Association residing in the 13 totally rural parishes. This number yielded a persons-per-dietitian ratio of 24,512, which was over three times the ratio of 7,772 derived from the parishes with urban centers of over 25,000 persons.

It is apparent from the above data that many persons were serving as dietitians in Louisiana who were not qualified and/or professionally related to the national association. This means that many schools, hospitals, and other health-concerned establishments can be assumed to be served at a subprofessional dietary level. The need for more dietitians seems clear in all parts of the state, but especially in rural areas.

Availability of Optometrists

There were 234 members of the Louisiana State Association of Optometrists in 1968, and 15,611 persons for each optometrist in the state (Table 10). Since many physicians are trained as ophthalmologists, there is no implication that availability of eye care can be fully assessed from the number of optometrists. However, the work of the latter is an important paramedical service.

Parishes with a persons-per-optometrist ratio below 10,000 were Acadia, Beauregard, Jefferson Davis, Caldwell, Winn, Vernon, and Avoyelles. Acadia Parish, with four optometrists, had a favorable ratio of 1,302. Beauregard, the second-ranked parish, had a ratio approximately four times that of Acadia. Caldwell Parish, although the fourth-ranked parish, had only one optometrist in residence. This high ranking was due to the relatively small parish population.

There were 18 parishes with no reported optometrist. Of these parishes, DeSoto, St. James, Pointe Coupee, St. John the Baptist, and East Feliciana had estimated populations of over 20,000 persons. These parishes plus Vermilion, St. Martin, and Iberville—all of which had estimated populations of over 30,000 and only one optometrist—represent areas where the need appears to be great.

Of the 13 totally rural parishes, nine had no optometrist living within their bounds. The remaining four rural parishes, taken collectively, had only five optometrists. In contrast, the nine parishes with urban centers of over 25,000 persons were found to have an average ratio of 14,503 persons per optometrist, and a range of ratios from 11,393 in Orleans Parish to 23,162 in Bossier Parish.

TABLE 10.—Number of Optometrists and Persons per Optometrist, by Parish, 1968*

		Persons per O.D.				Persons per O.D.	
Parish	No. of O.D.	Ratio	Rank	Parish	No. of O.D.	Ratio	Rank
Acadia	4	1,302	1	Madison	—	——	57
Allen	2	10,306	8	Morehouse	3	11,660	15
Ascension	3	11,043	12	Natchitoches	2	16,803	30
Assumption	—	——	58	Orleans	58	11,393	13
Avoyelles	4	9,532	7	Ouachita	7	16,710	28
Beauregard	4	4,906	2	Plaquemines	1	25,850	43
Bienville	1	16,365	27	Pointe Coupee	—	——	62
Bossier	3	23,162	40	Rapides	7	18,028	34
Caddo	12	20,897	36	Red River	—	——	50
Calcasieu	12	14,417	—	Richland	1	22,503	38
Caldwell	1	8,501	4	Sabine	—	——	59
Cameron	—	——	48	St. Bernard	2	24,040	42
Catahoula	—	——	51	St. Charles	2	14,638	23
Claiborne	1	16,715	29	St. Helena	—	——	49
Concordia	1	21,829	37	St. James	—	——	63
DeSoto	—	——	64	St. John the Baptist	—	——	61
E. Baton Rouge	19	14,738	24	St. Landry	7	12,226	18
E. Carroll	1	12,653	19	St. Martin	1	32,306	46
E. Feliciana	—	——	60	St. Mary	5	11,807	17
Evangeline	3	10,411	9	St. Tammany	5	10,562	10
Franklin	1	22,983	39	Tangipahoa	6	10,713	11
Grant	—	——	53	Tensas	—	——	52
Iberia	3	20,599	35	Terrebonne	5	15,111	25
Iberville	1	32,276	45	Union	—	——	56
Jackson	1	15,736	26	Vermilion	1	40,777	47
Jefferson	12	23,357	41	Vernon	2	9,115	6
Jefferson Davis	5	5,975	3	Washington	4	11,721	16
Lafayette	6	17,267	33	Webster	4	11,398	14
Lafourche	4	17,206	32	W. Baton Rouge	—	——	55
LaSalle	1	13,050	21	W. Carroll	1	12,739	20
Lincoln	1	29,389	44	W. Feliciana	—	——	54
Livingston	2	16,868	31				
				Louisiana	234	15,611	

*Roster, Louisiana State Association of Optometrists (1968).

Summary and Implications

The data presented in this report make it possible to assess trends in the availability and distribution of medical and paramedical personnel in Louisiana. In addition, in some instances it was possible to compare state and parish ratios with national norms. In this regard, when the three medical categories for which national ratios were available were compared with state ratios, Louisiana was in a uniformly unfavorable position (Table 11). Louisiana was 45.7 per cent above the national average in terms of number of persons per physician; 48.7 per cent above the national average in terms of number of persons per dentist; and 61.5 per cent above national norms in terms of number of persons per registered nurse.

TABLE 11.—Changes in Ratios of Persons per Physician, Dentist and Registered Nurse, for Degree of Urbanity, Louisiana and United States, 1950 and 1967

	Persons per physician				Persons per dentist				Persons per R.N.			
			Per cent change				Per cent change				Per cent change	
Category	1950	1967	Favor-able	Unfavor-able	1948[c]	1967	Favor-able	Unfavor-able	1949[c]	1967	Favor-able	Unfavor-able
Parishes with no population center of more than 2,500[a]	2,520	2,773		10.0	5,944	7,542		26.9	1,475	1,193	19.1	
Parishes with population centers over 2,500 but none 25,000 or more[a]	2,123	1,629	23.3		4,471	3,423	23.4		1,064	735	30.9	
Parishes with a population center of 25,000 or more[a]	621	545	12.2		1,821	2,059		13.1	263	355		35.0
Louisiana	985	931	5.5		2,670	2,615	2.1		435	483		11.0
United States[b]	742	639	13.8		1,938	1,758	9.3		501	299	54.3	

[a] These parishes were categorized according to 1960 census figures only.

[b] Statistical Abstract of the United States, 1954.

[c] 1950 data not available.

In the last two decades the position of the state in relation to national averages has worsened 12.9 per cent for physicians, 19.9 per cent for dentists, and 74.7 per cent for registered nurses. The discrepancies between the state and national situations with regard to the above medical personnel appear to be increasing with time. It is evident that Louisiana will remain in an unfavorable position in relation to national averages for persons per physician, dentist, and registered nurse unless remedial programs are inaugurated.

It is not as easy to generalize about the changes in the patterns of distribution of medical and paramedical personnel within the state. The degree and direction of change is different for each of the major medically-related occupations.

The ratios of persons per physician showed moderate drops over the last two decades in parishes with population centers of 25,000 or more, and for parishes with centers ranging from 2,500 to 25,000. However, there has been a very slight decrease in the ratio of persons per physician in totally rural areas.

Persons-per-dentist ratios changed for the better since 1948 only in those parishes with population centers between 2,500 and 25,000. However, this improvement is sufficient to make the statewide trend appear slightly favorable. Parishes without population centers over 2,500, and parishes with an urban center larger than 25,000 persons, show unfavorable trends in persons-per-dentist ratios. When considered in light of the fact that the rural parishes were already in a disadvantaged position, the 26.9 per cent change for the worse in these parishes is extremely significant for future planning.

The change in ratios of persons per registered nurse from 1949 to 1967 is also quite uneven. Favorable trends can be noted in rural parishes and in parishes with population centers ranging from 2,500 to 25,000. These changes are negated, however, by the extremely unfavorable trend in ratios of persons per registered nurse in parishes with population centers of 25,000 or more. The 35 per cent rise in ratios in these parishes over the past 18 years was sufficient to keep the statewide ratio of persons per registered nurse unfavorable. The latter trend attains greater significance in light of the fact that the national ratio of persons per registered nurse showed a 54.3 per cent change for the better in the same period of time that the state ratio worsened by 11 per cent.

Data were not available for longitudinal trend comparisons of paramedical personnel, including licensed practical nurses, medical technologists, radiologic technologists, physical therapists, dietitians, and optometrists. However, statewide ratios for these paramedical classifications were 609 persons per licensed practical nurse; 3,342 persons per medical technologist; 4,578 persons per radiologic technologist; 31,222 persons per physical therapist; 11,380 persons per dietitian, and 15,611 persons per optometrist.

Several basic conclusions can be drawn from an analysis of the data collected. First, it is clear that Louisiana is in a relatively disadvantaged position with regard to all levels of medically-related personnel. Second, it is obvious that the state has not made a great deal of progress toward

Farm Lagoons In Louisiana

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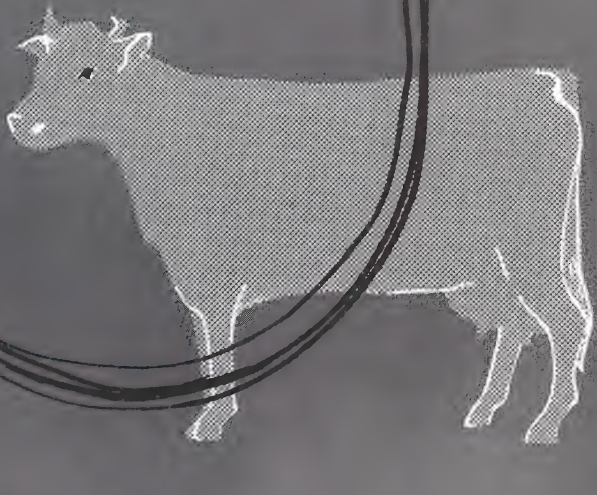

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Farm Lagoons in Louisiana

H. T. BARR, B. A. TOWER, C. D. STEELMAN, AND L. J. CABES, JR.[1]

Introduction

The increasing population of today is spreading into the farming areas surrounding our towns and cities. Dairies, poultry farms, and swine installations in many instances are being surrounded and enclosed by the incorporated city limits. The isolated farmland on which manure was formerly distributed is rapidly disappearing. In addition, an abundance of cheap manual labor for handling a bulky material of relatively low value no longer exists.

In various sections of the United States concentrated feed lots for beef cattle, swine, and poultry are rapidly expanding. A concentration of 25,000 to 200,000 caged laying hens, or 500 to 1,000 swine, or feed lots for 100 to 5,000 head of beef cattle in one location are becoming quite common. Such installations create problems in manure disposal and the avoidance of flies and objectionable odors.

A process of handling manure by the use of lagoons has gained a great deal of attention in the past few years. The process of oxidation is an old one that many cities practiced when they dumped raw sewage into streams; the excess water diluted the materials and the wave action and sunlight created conditions favorable for mechanical breakdown and bacterial action. The lagoon holds the manure in a condition favorable for its mechanical breakdown and oxidation to a point where it can be discharged into a body of water without harmful effects upon the animal and plant life of the stream.

Survey of Lagoons in Louisiana

The number of lagoons in Louisiana has increased rapidly during the past 10 years. As no permit is required in Louisiana in order to build a lagoon, the exact number built is not known; however, 44 were visited to collect data in a survey and the locations of some 40 more have been obtained since the survey. The Agricultural Engineering Department, both Research and Extension, have furnished information for the building of several installations. State health officials have assisted some owners who asked them for information. The Louisiana Wild Life and Fisheries Commission, Division of Water Pollution Control, periodically checks lagoon discharges if the discharge is into a body of water which supports a fish population.

The survey of some 60 lagoon users in Louisiana showed the users were well satisfied (two exceptions) with their operation and with a

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saving of approximately 50 per cent in labor required for cleaning the feeding floor in swine feeding. At the time of the survey, the lagoons visited had been in operation for periods of 10 days (new) up to 12 years, with none of the lagoons having been cleaned. Eighty-nine per cent of the lagoons were in use with swine feeding floors. Of the remainder, three were used with poultry, beef, and pork meat processing plants and the others with dairy, beef cattle feeding, and poultry operations. Several small towns and summer camps in Louisiana have reported satisfactory results with lagoons. However, the town and camp lagoons were not visited or included in the survey.

In the survey, the number of swine per lagoon varied from 50 to 620. Seventy per cent of the swine lagoons had no more odor than that of the feeding floor, 23 per cent had a slight odor, and 7 per cent had a very unpleasant odor. In the unsatisfactory group, two were poorly managed, with weeds growing around the sides, and were used as a means of disposal for small dead pigs and feed and fertilizer sacks. The third unsatisfactory lagoon, from the standpoint of odor, is a hole 100 feet deep washed out by a Mississippi River levee break. It has been in use as a lagoon for over 15 years and has a surface area of 225 square feet per animal of an average weight of 125 pounds. Because of the depth, this lagoon operates as an anaerobic unit and stays very dark in color, ranging from greenish black to black.

In the 70 per cent of lagoons that were operating as aerobic units without odor, the liquid varied from 3 to 5 or 6 feet deep. Several owners had dug their lagoons to 10 feet deep, but provided overflow at the 5- or 6-foot level, their plan being to raise the overflow with the accumulation of solids in the lagoon so as to keep a liquid depth of 3 to 5 feet. All of the lagoons in this group were green to greenish black or brown to pinkish red, depending on the organisms in the lagoon.

One-third of the lagoons were built against one side of the feeding floor (Figs. 3 and 4). The feeding floors were cleaned once or twice per day by hosing down with water. These lagoons varied from 10 to 40 feet in width and from 60 to 120 feet in length. Other lagoons were almost square, while some had been built by damming up a ravine and were of irregular shape. From the standpoint of efficiency of operation, the shape had no effect on the lagoon.

All of the lagoons were provided with overflows, but the majority had no overflow during the months of July and August. In dry weather two of the farmers with large lagoons would pump the material down to about 2 feet deep and use the liquid for irrigating cotton or a peach orchard.

With one exception, the feeding floors were all cleaned once or twice daily. The operators with water pressure of 25 to 40 psi (pounds per square inch) were also using a brush but were obtaining a low quality of cleaning. When 5 to 10 gpm (gallons per minute) were used at 60 to 100 psi with a ⅛-inch or ¼-inch nozzle, a high quality of floor cleaning resulted.

Studies With an Indoor Poultry House Lagoon

One of the two 14 ft. × 100 ft. laying cage houses on the LSU poultry farm was remodeled in 1963 by building a lagoon under the house. A total of 1,116 layers were placed in cages and on the slatted floor (416 in cages and 700 on the floor). The other house was used as a control, and 456 layers were placed in cages at the rate of one bird per 10-inch cage for the first two years. For the next three years the number of layers in the control house was doubled to 912 (two birds per 10-inch cage). At the end of the first year the cages in the lagoon house were removed and all the birds were loose-housed on the slatted floor of the house, with nests attached to the side walls, for the next three years. Beginning with the fifth year the birds in the lagoon house were placed in A-frame-type laying cages suspended over the open part of the lagoon as shown in Figure 1.

Since there were no good recommendations on materials to use for a floor for poultry over a lagoon, flooring was made a part of the project. Seven types of floors were used (See *A, B, C, D, E, F, G* in Fig. 2).

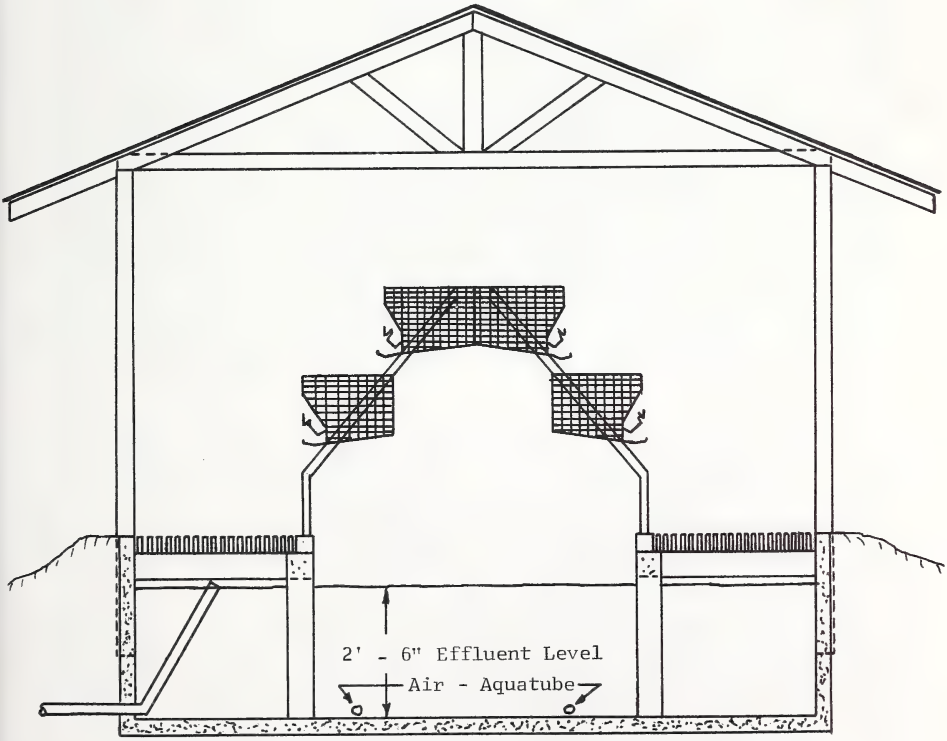


FIG. 1.—Cut Section of Lagoon Poultry House With Hens in Cages.

Examination of the floors of the lagoon house at the end of two years showed the following:

Floors A and B – The 14-gauge ¾-inch mesh expanded metal on both steel frames and creosoted 2 in. × 4 in. pine frames was no longer serviceable and was withdrawn from the test. This floor had been painted with two types of rust- and acid-resisting paint. Holes 6 inches to 12 inches had rusted out and had to be overlaid with patches in order to finish the second year.

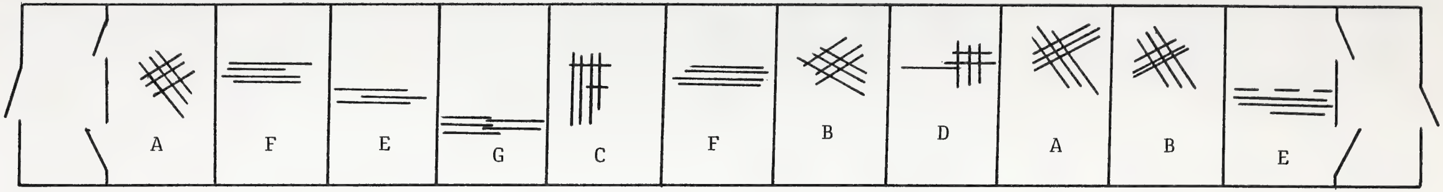
Floors C and D – The 14-gauge galvanized 1 in. × 2 in. mesh welded wire on both steel and creosoted 2 in. × 4 in. pine frames was no longer safe and was discarded. The wire had rusted and broken in numerous places and sagged badly where the egg gatherer had walked.

Floor E – The steel floor built up of inverted U-shaped pieces 1¾ inches wide set ¾ inch apart in 2 ft. × 8 ft. sections was badly rusted. Where the ends of the floor sections rested on the creosoted supports from one-third to one-half of the steel had rusted away and in many places the steel was pitted almost through. This floor was withdrawn from the test as it was doubtful whether it would last another four months. This was a commercially built floor of special steel, requiring no paint and introduced for dairy and swine floors. The floors have since been withdrawn from the market.

Floor F – The floor built of ⅝ in. × 4 in. creosote pressure-treated yellow pine pieces set on edge ¾ inch apart was in excellent condition after two years of service. This floor was removed for inspection, cleaned by using high pressure water, and reinstalled over part of the lagoon. A floor built in 4 ft. × 8 ft. sections from ¾ in. × 4 in. penta pressure-treated yellow pine pieces set on edge ¾ inch part was installed over the other part. The creosoted and penta pressure-treated yellow pine floors are now in their sixth and fourth seasons of use, respectively, serving as a walkway (Fig. 1) on either side of the cages. These floors are still in excellent condition and should last another 10 to 15 years or longer.

Floor G – A commercially built floor constructed from ½ in. × 1½ in. treated wood slats in 4 ft. × 4 ft. sections had numerous pieces split, warped, or broken. It was necessary to support this type floor at 4 feet on centers. The slats were spaced ¾ inch apart and held in place by wood dowels. This type floor was withdrawn as no longer serviceable at the end of two years.

During the winter months the sides of the poultry houses, which were built of chicken wire, were covered with a clear plastic curtain as a windbreak. With the house closed in, a slight odor was detected on some days by the farm laborers. To keep them satisfied and possibly get a more rapid digestion of the material in the lagoon, a source of oxygen was added. A ½-horsepower rotary air compressor was installed at the end of the poultry house. This compressor feeds 4 cubic feet of air per



A. 14 Gauge 3/4" expanded metal on wood frame.
B. 14 Gauge 3/4" expanded metal on steel frame.
C. 1" x 2" mesh welded galvanized wire on wood frame.
D. 1" x 2" mesh welded galvanized wire on steel frame.
E. Steel floor mfg. for hog slatted floors.
F. 1/2 of 5/8" x 4" pressure treated - 6# retention - creosoted yellow pine on edge spaced 3/4" apart and 1/2 of 3/4" x 4" penta treated yellow pine on edge spaced 3/4" apart.
G. 1/2" x 1 1/2" treated wood on edge spaced 5/8" apart.

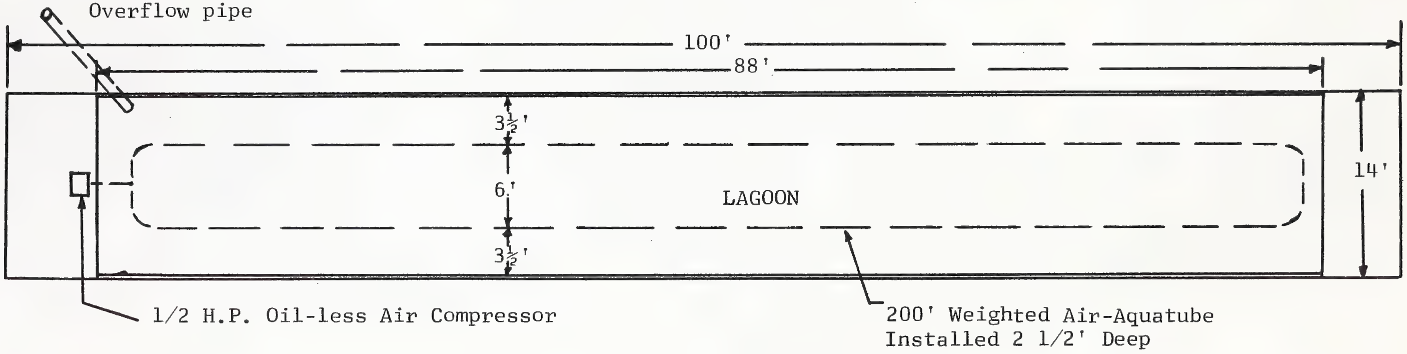


FIG. 2.—Floor Plan of Lagoon Poultry House With Hens on Floor.

minute at 15 pounds per square inch into 200 feet of perforated weighted tubing on the floor of the lagoon (Fig. 2). After air had been added at the rate of 4 cfm with 1,392 layers in the lagoon house, with the sides closed, only a very slight odor could be detected. This odor was no more noticeable than that of the control house.

A new flock of layers was put in the lagoon house each September. At the end of five years the lagoon was pumped out and cleaned. A composite sample of the soft sludge was dried down to a bone-dry weight. In the five years, 6,340 hens had been housed over the lagoon, leaving 36,558 pounds of manure (bone-dry weight), or 5.76 pounds per hen-year of 331 days. The depth of the effluent in the lagoon could be varied, but was maintained at very close to 2 cubic feet per hen throughout the five years.

At various times throughout the project a thin layer of suspended feathers and light manure (which contained fat from the feed) formed on the surface over some parts of the lagoon. This was easily broken up by agitation with a rake or hoe; however, a superior job was accomplished by using a small high-pressure stream of water. The pump used was connected to a ¾-inch water supply by using an ordinary ¾-inch garden hose. The ½-horsepower high pressure utility pump boosted the water pressure from 20 to 80 pounds, delivering 6 gallons per minute through a nozzle with a 3/16-inch opening. This type of pump did an excellent job cleaning up manure dried or wedged between floor members and in breaking up a floating layer of feathers and manure.

During the fifth year of operation a detailed study by a microbiologist on the bacteria present in the lagoon showed the lagoon to be operating at 70 per cent efficiency. The effluent from the lagoon was discharged into a shallow field ditch at a point 1,500 feet from a bayou that supported a population of fish. Additional oxidation and bacterial action took place in the ditch, with no odors or harm to the fish population in the bayou. Had the bayou been within 300 or 400 feet of the chicken house and lagoon, it would have been necessary to run the effluent into a second lagoon in order to hold the material for additional bacterial action.

A comparison of the results obtained with the lagoon house and the control house for five years showed very little difference in the performance of the birds in the two houses. However, there was a slight gain in weight at a reduced feed consumption for the hens in the lagoon house and a slight gain in production and egg weight for those in the control house.

A prejudice against eggs from a lagoon house had been voiced in some areas. A quantity of eggs from both the lagoon house and the control house was furnished the Home Economics Department. The eggs were cooked and submitted to a taste panel without any explanation as to source. The results were almost all in favor of the lagoon house.

Terramycin added to the feed at the rate of 200 grams per ton of feed to control mortality of chickens carried over into the lagoon and lowered all forms of bacteria, completely eliminating all coliforms for a 19-day period, after which they rapidly returned. Insecticides used at rates of 1 ppm (part per million) or less controlled mosquito breeding and caused no variations in the stabilization process. However, when an application of DDT was used in order to check a heavy infestation of poultry body lice, the number of bacterial organisms in the lagoon decreased in one week to .036 per cent of the previous number. After this there was a gradual increase, but it was two months before the number of organisms in the lagoon reached the previous level.

Studies With Swine and Beef Cattle Lagoons

Detailed studies were conducted with three lagoons for swine and one lagoon for beef cattle on the Experiment Station's Ben Hur farm. The first lagoon was designed 4.5 feet deep and on the basis of 40 square feet of surface area per 100 pounds of swine. This resulted in a lagoon 28 feet wide by 155 feet long and 4.5 feet deep. This lagoon was constructed and put into service in January 1962. When a new swine shed was built a second lagoon 4.5 feet deep was constructed on the basis of 35 square feet of surface area per 100 pounds of animal. This second lagoon was put into service in July 1962. A third lagoon was built on the basis of 50 square feet of surface area per 100 pounds of swine and put into service in September 1966. Since the size and number of swine in each pen varies throughout the year, the data represent only an average load. These three lagoons have dirt bottoms and sides except on the side next to the feeding floor, where a reinforced concrete side was built as a unit with the feeding floor (Figs. 3 and 4).

The feeding floors of the hog houses are cleaned normally once per day by using a ¾-inch hose equipped with a ¼-inch nozzle and water at 40 psi. All fecal materials and waste feed are washed off the floor directly into the lagoon.

Each lagoon is equipped with a 4-inch overflow pipe with a submerged inlet and empties into a small drainage ditch. During July and August there is seldom any overflow. During the remainder of the year, there is a variation of from 1 gallon per 5 minutes to 2 gallons per minute, not counting rainy days. Rain water from the feeding floors goes into the lagoons, but the lagoons are leveed so that surface water from the surrounding area does not enter. Three feet of water was put in each lagoon at the start and no overflow was noticed until the lagoons had been in operation approximately seven months.

The first lagoon developed greenish algae by the seventh month and the second lagoon pinkish red algae by the end of the second month. These two lagoons have been used continuously for seven years. During that time the algae numbers in both lagoons have shifted, giving the lagoons either a greenish or a reddish cast. Samples from the

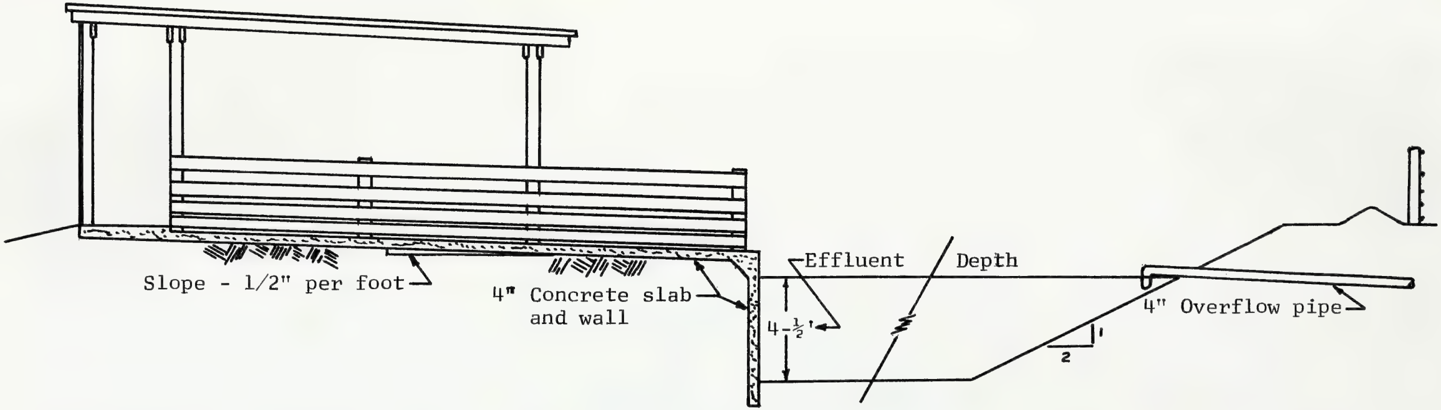


FIG. 3.—Cut Section of Typical Feeding Floor and Lagoon.

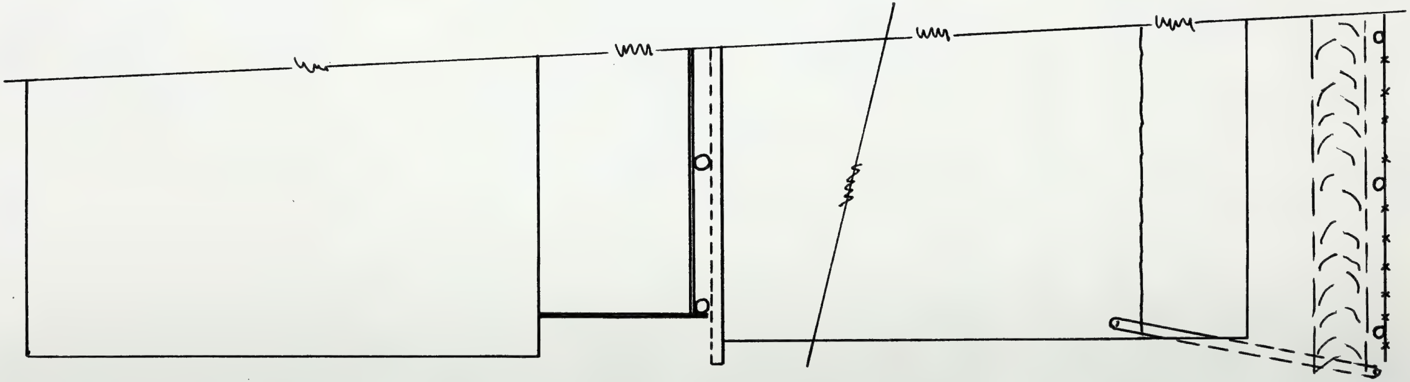


FIG. 4.—Partial Plan Section of Typical Feeding Floor and Lagoon.

lagoons and overflow were taken periodically over a three-year period by Louisiana Water Pollution Control personnel. Each report has been satisfactory or well below the tolerance established by the Louisiana Wild Life and Fisheries Commission.

On April 28, 1969, thirty-two measurements were made of the sediment in each of two swine lagoons and one beef cattle lagoon. The number of animals and their weights have varied during each year; however, numbers and weights were recorded at frequent intervals and the results shown are the averages.

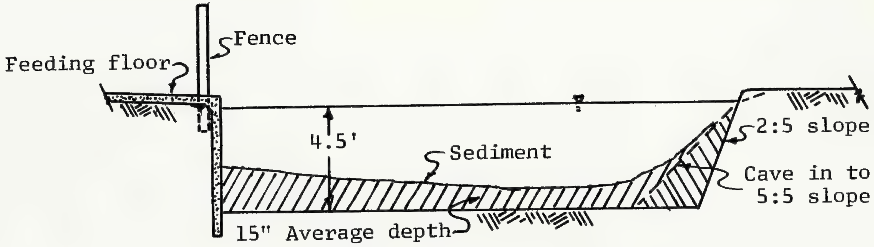
In lagoon A (Fig. 5), after 7 years and 3 months, there is an average of 15 inches of sediment and 39 inches of liquid, minus a small amount of cave-in on one side and the two ends. The original cut was on a slope of 2 horizontal and 5 deep but has now stabilized on a slope of 1 - 1. This lagoon was designed on a basis of 40 square feet of surface per 100 pounds of swine, and the usage has averaged out to 38 square feet per 100 pounds of swine. The lagoon has been in continuous service and has operated satisfactorily with no more odor than that of the feeding floor.

In lagoon B (Fig. 5), after 6 years and 10 months, there is an average of 29.5 inches of sediment and 24.5 inches of liquid, minus a small amount of cave-in. This lagoon was also cut with 2 feet horizontal to 5 feet depth and the soil ends and side soon stabilized on a 1 - 1 slope. This lagoon was built on the basis of 35 square feet per 100 pounds of swine, and the usage has averaged out to 34 square feet per 100 pounds of swine. The lagoon has been in continuous service similar to lagoon A but is accumulating sediment at a faster rate. There has been no odor from the lagoon and its operation has been satisfactory.

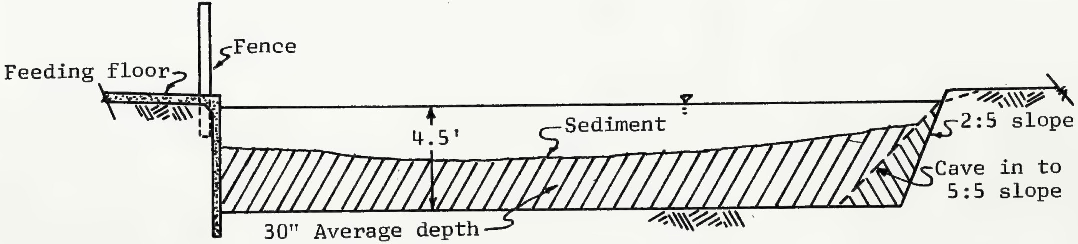
Lagoon C was built to take care of the animal waste from two concrete feeding lots for beef cattle as shown in Figs. 5, 6, and 7. This lagoon has been in use an average of seven months in each of six years, with cattle placed in the lots in the fall and removed about the end of April. An average of 115 beef animals weighing between 500 and 900 pounds have been fed in the lots each year. With the overflow set at 4 feet 6 inches, at the end of the sixth season there is an average of 23.5 inches of sediment and 30.5 inches of liquid in the lagoon. In washing down the floor a considerable quantity of waste hay was put in the lagoon during the first feeding season. This hay formed a floating, partly-submerged mat which decomposed very slowly and caused quite a bit of odor from the lagoon. After this hay was removed, the lagoon returned to satisfactory operation for the following five years.

In none of the lagoons was there found to be a build-up of the sediment against the concrete side of the lagoon where the material is washed off of the feeding floor (Fig. 5).

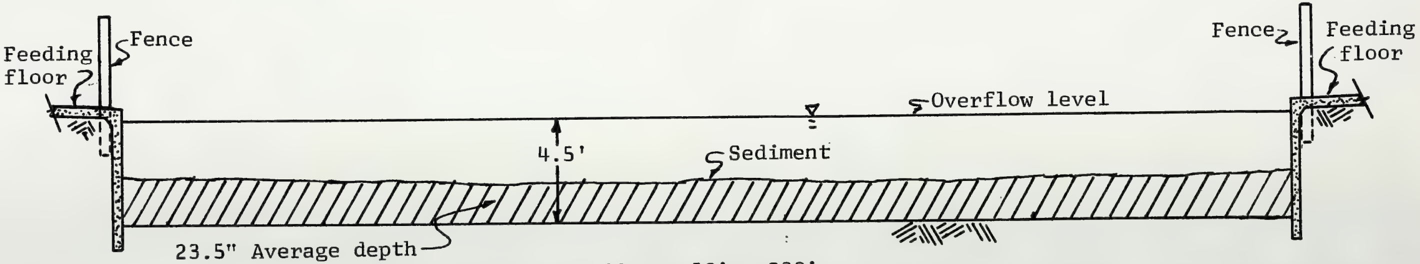
An overflow pipe should be made of 4- or 6-inch steel or cast iron with the inlet formed by an elbow extending 6 inches below the level to be maintained. Putting a drain pipe with inlet near the bottom of the



LAGOON A: 22.3' x 166'

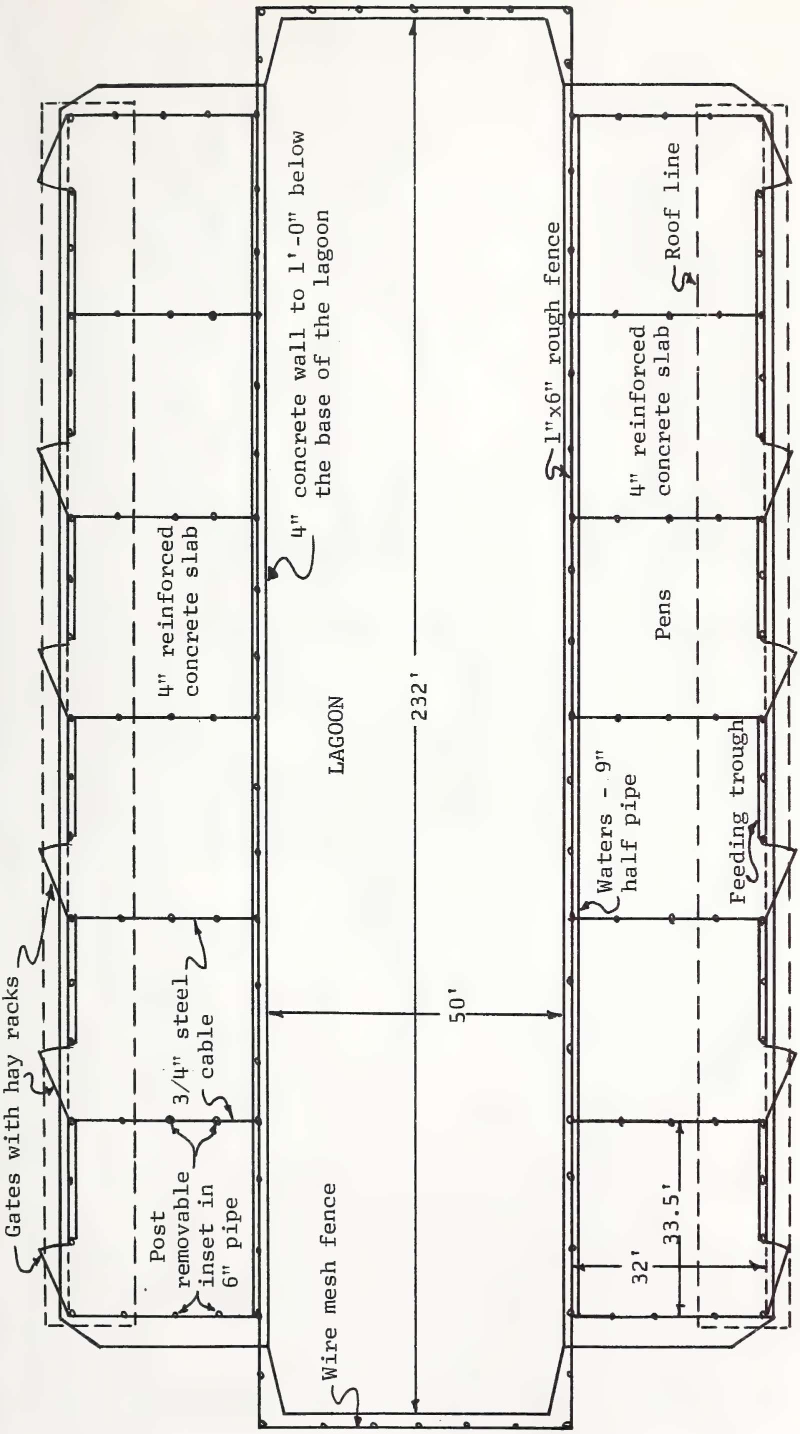


LAGOON B: 31' x 84'



LAGOON C: 50' x 230'

FIG. 5.—Cut Section Showing Sedimentation in Lagoons.



Gates with hay racks
Post removable inset in 6" pipe
3/4" steel cable
4" reinforced concrete slab
4" concrete wall to 1'-0" below the base of the lagoon
Wire mesh fence
LAGOON
232'
50'
1"x6" rough fence
Waters - 9" half pipe
4" reinforced concrete slab
Pens
32'
33.5'
Feeding trough
Roof line

FIG. 6.—Lagoon Serving Two Concrete Feed Lots for Beef Cattle.

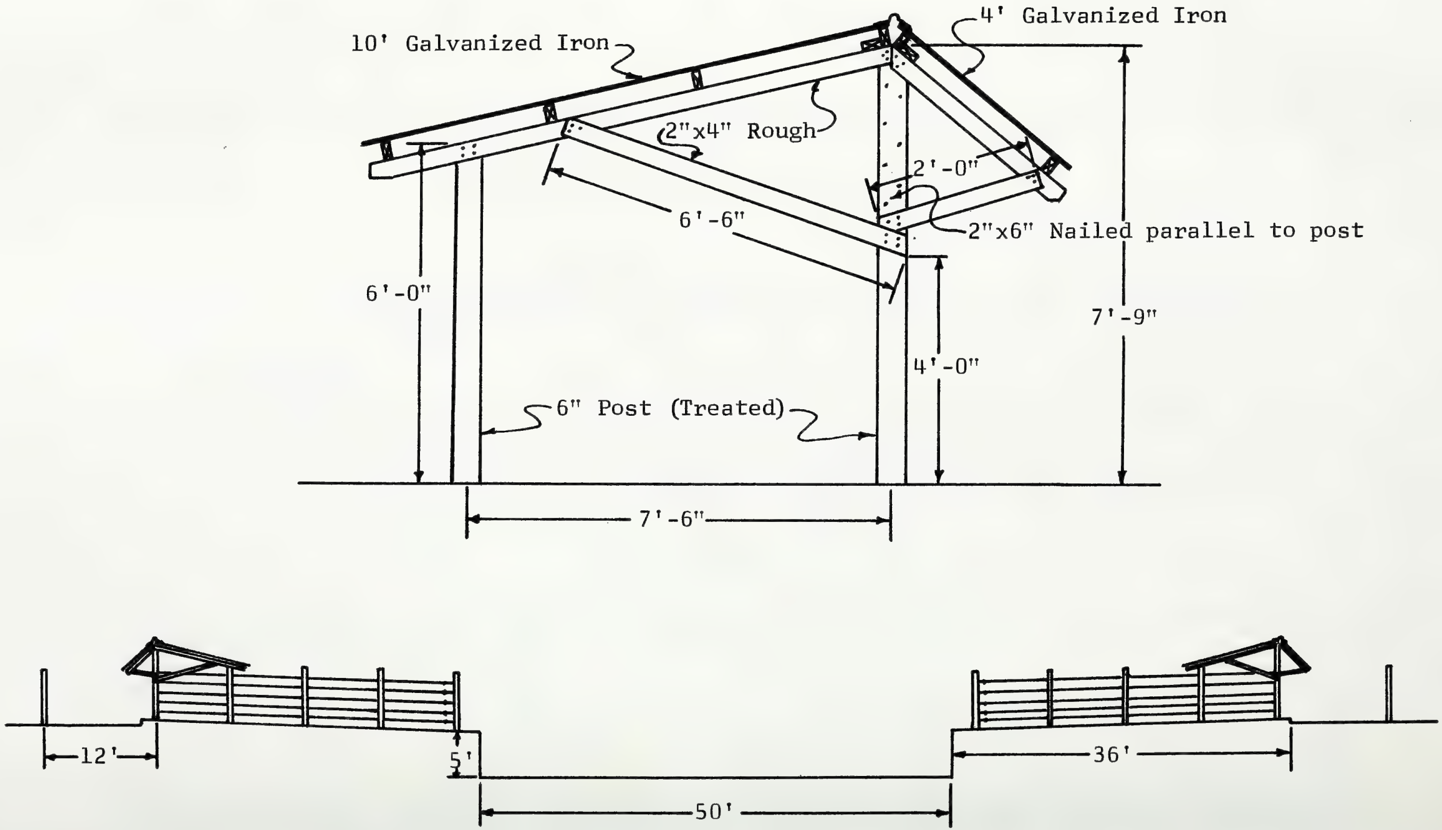


FIG. 7.—Partial Detail of Shed and Fenced Beef Cattle Feed Lot With Lagoon.

lagoon with an elbow and riser on the outside is recommended by some. This allows easy regulation of the water level by turning the elbow. This scheme was tried on two lagoons, but frequent clogging occurred from sediment in the pipe and on one occasion a turtle became wedged in the pipe.

Sediment in the drain pipe can be blown back into the lagoon by using high pressure water (60 to 100 psi) such as used for washing down the feeding floors, or with a portable air compressor. However, a wedged turtle will generally require a stiff wire or cable to be pushed through and then a swab of some sort pulled through to dislodge the turtle and sediment.

Cleaning of a clogged submerged lagoon drain is a very messy and unpleasant chore. No clogging has been experienced with the top drain location with the inlet submerged 6 inches below overflow level.

The easiest, quickest, and most convenient method of cleaning a lagoon is to use a pump manufactured for handling liquid manure. Connect a string of 4-inch aluminum irrigation pipe discharging onto a field that is to be plowed or onto a grassy area. Keep the sediment stirred up and most of it will be removed; however, it may be necessary to partly refill with water and stir up the remaining sediment to get a satisfactory quantity removed. Lagoon sediment was pumped onto a grassy plot 500 feet from two residences and no objectionable odor from the sediment was noted at the residences.

Use of Oxidation Ditches

A new manure-disposal system for a swine farrowing barn and a swine nursery barn on LSU Ben Hur farm was put into operation during the spring of 1969. These buildings are equipped with slatted floors so that the manure falls through into a lagoon or oxidation ditch located beneath the building. The oxidation ditch is equipped with a paddle wheel that whips air into the swine waste and water. The material circulates in a race track-shaped oval under the building, with a small amount of overflow passing off into a drainage ditch. The wheel runs continuously. This process with some minor variations has been in use in various European countries for many years. Several such installations have been installed in the United States within the past three years.

The oxidation ditches installed in the United States for handling animal waste vary considerably in shape of the cross section of the ditch, type of rotary wheel, and ditch capacity per animal. Six state agricultural experiment stations and two commercial companies are known to be experimenting with oxidation ditches in an attempt to determine the most efficient shape and size of rotary wheel, shape of ditch, method of removing overflow, and ditch capacity needed per animal.

Oxidation ditches are in use with the capacity varying from 12 to 60 cubic feet per hog and from 80 to 90 cubic feet per dairy cow. The

LSU maternity hog oxidation ditch is operating satisfactorily at 18 inches of depth, or 30 cubic feet per sow and litter. Some foaming was experienced two to three weeks after placing the sows in the pens, but this soon disappeared and is no longer a problem.

The effluent from an oxidation ditch should be run into an aerobic lagoon for further bacterial action before discharging it into a stream. Accumulated sludge will have to be removed periodically from an oxidation ditch by a vacuum wagon or sludge pump. Sludge can be flushed out by building the bottom of the oxidation ditch above grade and installing a 4- or 6-inch cast iron pipe at the lowest level of the ditch.

Controlling Mosquitoes in Lagoons

The introduction of livestock organic waste into an impounded body of water, such as a lagoon, creates an excellent breeding place for the southern house mosquito *Culex pipiens quinquefasciatus* Say. This mosquito is an important vector of St. Louis encephalitis as well as dog heartworm. Mosquito activity in the lagoons begins in early May and persists until November, with larval populations as high as six million per acre observed in swine lagoons in Louisiana.

Emulsifiable concentrate formulations of several insecticides were applied in order to determine which materials: (1) provide 100 per cent control of mosquito larvae within 24 hours; (2) provide residual chemical action sufficient to kill reinfesting mosquitoes over a three-week or longer period; and (3) cause no appreciable reduction of the bacterial population in the lagoon. Prior to testing it was necessary to calculate the volume of water in each lagoon. The amount of insecticide required for each lagoon was calculated as follows:

1. Length in feet × width × depth = number cubic feet of water in lagoon.
2. Number cubic feet of water in lagoon × number gallons water per cubic foot (7.5).
3. Number gallons water in lagoon then used in standard insecticide spray formula to calculate amount of emulsifiable material required to produce a .0001 per cent (1 part per million) concentration in total water volume of the lagoon. Thus, per cent concentration desired in lagoon × number gallons water in lagoon ÷ per cent emulsifiable concentrate = gallon(s) insecticide required in lagoon to give desired concentration (1 ppm, or .0001 per cent).

Laboratory tests were conducted to determine the amount of mortality to bacterial organisms caused by various insecticide materials. The bacterial mortality in waste disposal lagoon water after treatment with 0.0001 per cent (1 ppm) selected insecticide materials is shown in Table 1. Low bacterial mortality resulted from the 1 ppm concentrations of all the test insecticides. In operating lagoons the addition of

TABLE 1.—Bacterial Mortality in Lagoon Water After Treatment With 0.0001 Per Cent (1 ppm) Selected Insecticide Materials

Insecticide	Per cent mortality 24 hr. after treatment[1]
Abate	0.0
Dursban	0.0
Naled	0.83
Baygon	1.66
Malathion	0.83
Fenthion	1.25

[1] Untreated lagoon water contained 24 million bacteria per milliliter.

water to wash the fecal material into the lagoon would tend to dilute the insecticide concentration during the 24-hour period, which presumably would further reduce bacterial mortality.

Bacterial mortality as low as that found in this study would not cause a functional disruption of the lagoon process. The daily addition of fecal material along with bacterial development in a lagoon could offset the bacterial mortality resulting from the use of insecticides at 1 ppm or less to control mosquito breeding.

Three methods of application were used to treat the lagoons. In all methods sufficient insecticide was used to provide 1 ppm in the lagoon water. In the first method the insecticide was added to 50 gallons of water and applied to the surface of the lagoon with a power sprayer operating at 150 psi. In the second method the spray gun was removed and the hose was dragged along the bottom of the lagoon as the insecticide solution was being dispensed under pressure. In the third method the required insecticide was dispensed in 3 gallons of water with a hand-pump sprayer equipped with a fan-type nozzle. The solution was applied to the surface of the lagoon in a band 3 feet wide around the margins of the lagoon.

As shown in Table 2, the 1 ppm application of Dursban® gave 144 days of 100 per cent control of mosquito larvae. Abate®, Baygon®, Dibrom®, and Baytex® provided 18 to 20 days of 100 per cent control and Malathion provided 2 days of 100 per cent control.

TABLE 2.—Control of Larval Mosquitoes in Waste Disposal Lagoons

Insecticide[1]	Number days 100 per cent control
Malathion	2
Baytex	18
Dibrom	19
Baygon	20
Abate	20
Dursban	144

[1] Each emulsifiable concentrate formulation used at 1 ppm concentration in the total volume of lagoon water.

No difference in effectiveness of mosquito control was detected between the three methods of application. However, the method utilizing the 3-gallon hand-pump sprayer is perhaps the most desirable since this sprayer is available on most farms and is easy to move around during application. These field test data show that residual chemical action retained in lagoons treated with 1 ppm concentrations is sufficient to provide continued mosquito control until the chemical is broken down or diluted below the required lethal level. No bacterial mortality occurred as a result of treating the lagoons with 1 ppm concentrations of the materials tested. The length of time that effective mosquito control continues will vary depending on the insecticide material selected and the rate of dilution of the chemical.

Summary and Recommendations

A survey of some 60 lagoon users in Louisiana showed almost all of the users were well satisfied with their operation and with a saving of approximately 50 per cent in labor required for cleaning the feeding floor in swine feeding.

None of the lagoons for swine covered in the survey had been cleaned. The age of the lagoons varied from less than one year to 12 years. The lagoons for swine that had been in use two or more years and were operating satisfactorily had been built with at least 32 square feet of surface area and 180 cubic feet of capacity per 100 pounds of animal.

Although the indoor poultry lagoon produced no algae, the results of the five-year study show the feasibility of such lagoons and their possible use, especially when prices of land and space are at a premium.

Tests on the biochemical oxygen demand showed the indoor lagoon for poultry to be operating at 74 per cent efficiency. The additional oxygen requirement of the effluent at this efficiency is too high to allow direct discharge into a stream or lake. When built under the house a poultry lagoon should have a capacity of 4 cubic feet per hen, or the effluent from a lagoon of 2.5 cubic feet per hen should be discharged into an open lagoon of equal or slightly smaller size to allow for further retention and bacterial action.

Eight types of flooring were used over the indoor poultry lagoon. Best results were obtained from the floors built of either 5/8 in. × 4 in. creosote pressure-treated yellow pine set on edge 3/4 inch apart or 3/4 inch × 4 in. penta pressure-treated yellow pine set on edge 3/4 inch apart.

A comparison of five-year results with the control house and the lagoon house for poultry showed that the birds performed equally well in either environment. The production, egg weight, feed per dozen eggs, and quality were almost equal.

Mosquito breeding in the indoor poultry lagoon was controlled by insecticides used at 1 ppm (.0001 per cent). This concentration caused no appreciable decrease in the bacteria or the stabilization process. The insecticides used with the least detrimental effect to bacteria were Abate and Dursban at this concentration.

Based on the survey and experimental results, a lagoon for swine should be built 5 feet deep, with 40 square feet of surface area and 180 to 200 cubic feet of capacity per 100 pounds of animal. If the lagoon is built adjacent to the feeding floor, pour a reinforced 4-inch concrete wall as a single unit with the feeding floor so as to prevent the dirt from being washed out and undermining the floor. Slope the dirt side and ends of the lagoon to a proportion of 2 feet horizontal and 1 foot vertical, or 3 feet to 1 foot, depending on the soil type, so as to prevent caving in. Levee the lagoon so as to prevent entrance of surface water and fence it to keep out livestock.

Mosquito and fly infestation can be partly eliminated by preventing grass, weeds, rushes, and brush in or near the edge of the lagoon. A 100 per cent control of mosquitoes in an open lagoon can be obtained for 21 weeks with 1 ppm (.0001 per cent) of Dursban and for approximately 3 weeks with 1 ppm (.0001 per cent) of Abate, Baygon, Dibrom, or Baytex.

The number of house flies at the LSU poultry, swine, and beef cattle lagoons was negligible. At various times a few soldier fly larvae were found.

A lagoon should not be considered as a disposal medium for all materials. It should not be used as a catchall for dead animals, feed and fertilizer sacks, or floor sweepings of straw, shavings, hay, trash, and the like.

The following factors should be considered when construction of a lagoon is under consideration:

(1) Is there sufficient land adjacent to the feeding installation for the lagoon?

(2) Is the price of the land such that it is economical to use it for a lagoon?

(3) Is the slope of the land such that the lagoon can have a levee around it to prevent drainage from adjacent area?

(4) Is there a suitable drain or stream into which the lagoon overflow may empty?

(5) Is the soil of such a character that the lagoon will hold water?

(6) Is the location of the lagoon such as not to contaminate nearby wells?

(7) Is there sufficient water supply to fill the lagoon?

(8) Is the quantity of water and pressure adequate for washing down the floors?

(9) Is it possible to locate the lagoon down-wind from any nearby installation or establishment?

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Potential Roles of Local Opinion Leaders In the Communication of Forest Fire Prevention Messages

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IN COOPERATION WITH
SOUTHERN FOREST EXPERIMENT STATION
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

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Preface

This bulletin represents another step in the research effort sponsored cooperatively by the Fire Prevention Research Project, Southern Forest Experiment Station of the U.S. Forest Service, and the Department of Rural Sociology at Louisiana State University. The work on this particular study also involved cooperation with members of the Mississippi State University Social Science Research Center.

The research project for this report was administered through the Department of Rural Sociology, Louisiana State University.

The authors wish to express appreciation for the cooperation and assistance given them by members of the Fire Prevention Research project team and the Mississippi State University Social Science Research Institute. Special recognition is deserved by: Mr. Tony Altobellis, Mr. Wesley Baird, Mr. Larry Doolittle, Mr. Merlin J. Dixon, Dr. Arthur Jones, Dr. Harold Kaufman, Dr. Berch W. Henry, Dr. William Heffernan, and Dr. Pedro Hernandez.

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Potential Roles of Local Opinion Leaders In the Communication of Forest Fire Prevention Messages

LOUISIANA STATE UNIVERSITY LIBRARY

Ben E. Dickerson and Alvin L. Bertrand*

Introduction

The study described in this report was designed to contribute at the practical level to the fire prevention objectives of the Southern Forest Experiment Station, the various State Forestry Commissions, and other agencies devoted to lowering the rate of forest incendiarism. Continued high rates of man-caused woods fires indicate that fire prevention messages have not been effectively communicated in certain communities and neighborhoods. The Southern region of the United States, for example, has had a 38.1 per cent increase in number of fires and a 66.2 per cent increase in the number of acres burned from 1961 to 1967.[1] Yet this region has been the consistent target of mass media and other types of messages designed to change existing fire attitudes and practices. The problem, as reported by Griessman and Bertrand, is not one of fire prevention message reception.[2] Rather, it is one of selective perception. The woods burner does not perceive that the messages being sent via TV, radio, newspapers, or bill boards have relevance for his activities. His selective interpretation of fire information received via the mass media apparently is rationalized in terms of economic and other motives which lie behind deliberate fire setting activities in rural communities.[3]

The above suggests that, to transmit successfully fire prevention messages, approaches to communication in some areas must be different from those used in other places. A clue to an approach that has been successful in certain rural communities was suggested by the findings of a recent study made by Doolittle.[4] He found the planners of successful forest fire prevention programs had made use of knowledge obtained about leadership and inter-group relations to determine individuals who might play a key role in transmitting fire prevention messages. The study reported here was designed to test Doolittle's conclusion within a particular setting.

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[1] Southern region, as here defined, includes: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Oklahoma, Tennessee, and Texas. See the summaries of "Forest Fire Statistics" (1964 to 1967), prepared by the Division of Cooperative Forest Fire Control, Forest Service, U.S. Department of Agriculture.

[2] Eugene Griessman and Alvin L. Bertrand, *Factors Related to Communication of Forest Fire Prevention Messages*, Louisiana Agricultural Experiment Station Bulletin No. 623, Baton Rouge: Louisiana State University and Agricultural and Mechanical College, 1967.

[3] Arthur R. Jones, M. Lee Taylor, and Alvin L. Bertrand, *Some Human Factors in Woods Burning*, Louisiana Agricultural Experiment Station Bulletin No. 601, Baton Rouge: Louisiana State University and Agricultural and Mechanical College, 1965.

[4] Max Larry Doolittle, "Forest Residents and Forest Fires: A Case Study Approach," unpublished Master's thesis, Mississippi State University, State College, 1967.

Objectives of the Study

The study was designed in light of the clues outlined above and took its basic inspiration from the fact that no one had investigated the role that local leaders might play or could potentially play in the effective communication of fire prevention messages. The specific aims in mind were: (1) To identify the various individuals who might influence woods residents to change their practice of burning. This type of individual was considered to be the intervening link or factor in the communication process from the sender to the recipient of a fire prevention message.[5] (2) To identify, describe, and analyze the types of communicator roles played by these opinion leaders and to classify these roles according to their characteristics. It was assumed that if something were known of the behavior of local leaders, it would be feasible to approach them for assistance in decreasing the rate of forest fires within their local setting. (3) To characterize individuals playing the various types of communicator roles in terms of their personal-social characteristics, and their attitudes toward forest fire. With regard to this aim, it was considered worthwhile to determine if opinion leaders represented a special type of person and if such persons tended to have negative views toward fire prevention.

The Study Area

The study community was selected in collaboration with Forest Service personnel and other knowledgeable persons. Star community was selected for several reasons.[6] The community is located in the rural South, where there is a high incidence of man-caused forest fires. In addition there was forest land within the study location which was protected by national, state, and private fire control agencies. Finally, the community selected had not been the site of previous investigations, and there was no fear of research "contamination."

The part of the community studied included approximately 240 families and covered an area of 42 square miles. A large corporation owned about 1,400 acres near the center of the geographical area of Star. Almost 30 per cent of the remaining land area was divided in ownership plots of 500 acres or more, with the largest individual holding totaling some 1,800 acres. The remainder of the holdings were small (under a hundred acres) and were owned by individuals who worked part-time elsewhere.

The area was heavily forested and the rate of forest fires was extremely high. Fire occurrence rates for the study area had averaged 18 to 20 per cent higher during the period 1959-60 through 1966-67 than the rates for the entire county in which it was located.

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[5] Melvin L. DeFleur, *Theories of Mass Communication*, New York: David McKay Company, Inc., 1966, pp. 129-133.

[6] The real name of the community is not given, in the interest of anonymity.

Three small Protestant churches served the area. The school in the community had recently closed, and the students from the area were attending schools located outside of the community. The population studied was made up of neighbor groups which formed part of the community area trading center.[7] This pattern of settlement and social organization has relevance in that it is typical of many areas within the rural South.

Methodological Procedures

Several procedures were used in the implementation of the study. The first problem was the identification of local opinion leaders. Two procedures were followed in order to have a validation check. First, a directive interview was conducted with every household head in the area.[8] Completed questionnaires were obtained from 230 of the 244 resident household heads. Each of these respondents was asked to identify persons whom he considered to be neighborhood influentials, that is, persons whose opinions were respected with regard to local issues. Some 144 persons were identified, but only 38 names were mentioned as often as three times. Pertinent information about the respondents and their families, such as age, education, income, social participation, and their beliefs and attitudes about woodlands and woods burning, was also obtained.

The second research approach was in the nature of a focused interview with a sample of 18 community leaders (not necessarily residents of the study neighborhood area). The latter were selected because of their position, such as county agent, professional foresters, ministers, and bankers.[9] These individuals were also asked to identify the opinion leaders in the study locale. Persons who were identified by both neighborhood household heads and formal community leaders as being influential on local issues were considered to be opinion leaders. Thirty such leaders were identified by name in this manner, although one refused to participate in the study.

The third procedural step was to interview a selected number (12) of the opinion leaders identified in the first two steps to determine what type of communicator roles they played. In order to determine the nature of the communicator roles an opinion leader played, he was asked what part he or other persons played in connection with three selected issues that had faced the people in the study locale within the past decade.[10] These issues were: whether or not to consolidate schools, how to dispose of vacated school properties once consolidation was accomplished, and whether or not to establish and pay for a community water system. The responses of these individuals indicated what they and others had done, and it was possible to determine that they had played three communicator type roles. These roles will be identified in a later section of this report.

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[7] Bardin Nelson's definition of the rural neighborhood was used in this research: "A rural neighborhood is a group of people experiencing social interaction within a localized area with one or two social institutions as the focal point or means by which the area can be identified physically." See: Alvin L. Bertrand, *Rural Sociology*, New York: McGraw-Hill Book Company, Inc., 1956, Chapter 6.

[8] The directive interview technique is based on a predetermined set of questions asked of respondents interviewed.

[9] The focused interview is different from other interview techniques in that (1) it takes place with persons known to have been involved in a particular concrete situation, (2) it refers specifically to situations which have been analyzed prior to the interview, (3) it proceeds on the basis of an interview guide which outlines the major areas of inquiry, and (4) it is focused on subjective experiences.

The Approach of the Study

From a theoretical standpoint, the study was conceived as falling within the realm of role theory. The problem was the isolation and classification of roles related to the communication of messages in neighborhood groups. In this regard, the findings of previous research suggested that informal social relationships played significant roles in modifying the manner in which a given individual would act upon a message which came to his attention via mass media.[11] Therefore, it was conceived that fire prevention messages would have to be transmitted within the context of local actors in a local setting to be effective in communities such as the study locale. This point of view was in keeping with a theory proposed by Paul Lazarsfeld and his colleagues. They suggested that communication on certain issues and in certain settings is not a direct process, but rather a two-step flow of information. The first step involves the interception of messages from TV, radio, and press, and the second step is the interpretation of these messages to actors within local settings, such as homes, neighborhoods, and communities.[12] The interactional mechanisms through which a message is processed are reciprocal role relations.[13] Roles, as structural parts of status-positions, thus serve to link two positions. Within the above frame of reference, it was conceived that the status-position of an opinion leader could serve as the focus for the second step in the two-step flow of communication, because it ostensibly contained a communicator role in its make-up. This assumption set the stage for the analysis which follows.

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[10] Members of the study area were selected at random and were asked to name the five most important issues confronting them and their neighbors in the last few years. The three issues selected were the ones most often mentioned.

[11] DeFleur, *op. cit.*

[12] Paul F. Lazarfeld, Bernard Berelson, and Hazel Goudet, *The People's Choice,* New York: Columbia University Press, 1948.

[13] Frederick L. Bates, "Positions, Status and Role: A Reformulation of Concepts," *Social Forces,* Vol. 34, No. 4, May 1956, pp. 313-321, and "Institutions, Organizations, and Communities: A General Theory of Complex Structures," *The Pacific Sociological Review,* Vol. 3, No. 2, Fall 1960, pp. 59-70; Robert J. Dolan, "An Analysis of the Role Structure of a Complex Occupation with Special Emphasis on the Value and Role Orientations Associated With the County Agent Status," Ph.D. dissertation, Louisiana State University, June 1963, Vol. I; and Alvin L. Bertrand, *Basic Sociology,* New York: Appleton-Century-Crofts, Inc., 1967.

Local Opinion Leaders and the Communication Process

Identification of Opinion Leaders

The interviews conducted with household heads in the study area were, as mentioned, the first step in the identification of local opinion leaders. Some 144 persons were named by the 230 individuals interviewed in response to the question, "Who are the individuals whose opinion you respect most with regard to important local issues?" The fact that 38 names were mentioned three or more times provided some evidence for the identification of the most respected opinion leaders.

At this point it is of interest to review the reasons given for naming a person as a leader. Each of the respondents interviewed was invited to give some reason or reasons for selecting the individuals he named as influential or important to the community. Answers to this question were tabulated and seven categories of responses were isolated. (See Table 1.) More reasons than interviewees appear because some individuals gave more than one reason for naming a particular leader.

TABLE 1.—Respondents' Reasons for Selecting Individuals as Opinion Leaders

Perceived Reasons	Number	Per Cent
Community involvement	85	12.6
Religious involvement	45	6.7
Community service	100	14.8
Personal traits	128	19.0
Significant other*	238	35.4
Personal services	50	7.4
Miscellaneous	27	4.1
Total	673	100.0

*"Significant other" refers to any person whom another individual identifies with and uses as a standard for self-evaluation and as a source for personal values and goals.

A scrutiny of Table 1 shows two interesting findings: (1) a relatively large percentage of respondents named a person or persons as leaders because he or they were "significant others," and (2) the importance attached to community involvement (including community service) as a criterion for leadership.

The implication of these two findings appears to be the pattern by which local people organize their relationship with one another. In other words, it appears that greater emphasis is given to the network of friendship relations and practice of mutual cooperation in neighbor groups than to other activities.[14]

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[14] A neighbor group is composed of a network of primary relationships with no definite membership boundaries—often 5 to 15 rural families. See: Selz C. Mayo and William E. Barnett, "Neighbor-Group—An Informal System of Communities," *Rural Sociology,* 1952, pp. 337-371.

Determination of Communicator Roles of Opinion Leaders

From the interviews with opinion leaders it was determined that they and others had clearly played several roles of the communicator type. For example, certain individuals were responsible for beginning talk about the water system. These individuals apparently had been in touch with representatives of the Federal Housing Authority and had been informed that federal financial assistance was available for community water systems. They no doubt had also become convinced of the superiority of a central or collective system over individual wells and pumps. The source of the latter feeling is difficult to trace but can be assumed to be related to experience with town water systems.

Other persons were identified as the ones initiating discussion on the school consolidation program. It was determined that these individuals had had discussions with local and state school officials who had convinced them of the necessity, in an economic sense, of consolidated schools. The argument raised was that there were not enough tax revenues to support more than one school. Some five different leaders were found to have been the source of ideas for use and disposal of the vacated school property.

In the latter instance, it appears that the inspiration for action was entirely a local phenomenon. Four of the five initiators had a different notion as to how the vacated school property could best be used. One leader wanted a trade school set up, another wanted an "old folks" home for local people, a third wanted a community center for various types of civic activities, and a fourth wanted to sell the buildings to local churches. It is of note that this issue has not been settled to date. The thesis of the writers is that it has taken a relatively long time to get the various leaders to agree on one "best" plan, whereas in the instance of the first two issues—both culminated successfully—this problem did not exist. The study area is now served by a community-wide water system and a consolidated school. The facts that there were no leaders offering strong alternatives and that help was obtained from outside the area no doubt helped bring these actions about.

Interestingly, it was also discovered that certain opinion leaders did not initiate messages but were convinced of the worth of the idea from listening to the initiators of messages and began relaying what they had heard to others in the area. Still others consulted with the first set of local leaders to determine if they had heard the right message and were interpreting correctly the action advocated. Once reassured on this score, they had proceeded to serve as a communicator of the message to local neighborhood groups in which they held positions of influence. All in all, it became evident that local action was in large part a function of communication on the part of local opinion leaders—to one another and to other local people.

Classification of Communicator Roles Played by Opinion Leaders

Contemplation of the above patterns of communication suggested that there was not one but three types of communicator roles played by local opinion leaders. Each of these roles could be seen as active at one time or another and in a different contextual setting.

The first type of communicator role was classed as an initiator role in that the actor originated the message within local circles. In other words, he was the first to bring the information into the area. At this point, it should be noted that the respondents' answers to queries relative to the kind of role played by a local leader made it possible to classify these leaders according to the communicator roles delineated. In instances where it was apparent a leader played more than one role, he was classed in the more important role group. A tabulation of the response received showed high agreement (83 per cent) as to who played the initiation role in connection with the various issues mentioned before.

Those playing initiator roles apparently influenced the persons who played the next type of communicator role. This second type was tagged a legitimizer role in that the opinion leader who played the role affirmed the worth of the message brought by the initiator and thus enhanced its chances for positive reception. Usually the legitimizer's contacts were more widespread than those of the initiator but still did not reach everyone. There was also a strong consensus (81 per cent) on the individuals who played this type of role, as determined by a review of their comments.

The third level of communicator role played was classed as a diffuser role. The opinion leaders playing this role took their cues from those serving as legitimizers and carried the message to clusters of families over whom they exercised influence. Again, it was possible to determine that there was overwhelming agreement (91 per cent) on the leaders who played this type of role.

It should be noted that the type of communicator role played by an opinion leader varied from issue to issue. This variation was obviously a function of the interests of the leader. Some of them felt more involved or felt they had more to gain by promoting certain issues. In this regard it seems a good strategy for action programs would be to attempt to interest local leaders in the aims of the program. To illustrate, the leader who wishes to start some kind of action would make an effort to contact and convince a certain number of other leaders, so that they would become his legitimizers and diffusers. However, he himself could and would play legitimizer and diffuser roles. Every opinion leader, it was discovered, had a group of families over whom he exercised almost total influence, achieved through kinship and other structural relations.[15] He was thus in a position to play all three types of communicator roles. However, it was clear that the majority of those playing diffuser roles seldom played initiator or legitimizer roles. By contrast, those playing initiator roles almost always played the other two roles also. Legitimizers were also always diffusers and occasionally served as initiators of messages. It should be noted that all leaders were classed according to the role they played most often.

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[15] Donald J. Shoemaker and Harold L. Nix have elaborated a notion of exchange relationships which give opinion leaders their position of power. See: Donald J. Shoemaker and Harold L. Nix, "The Accumulation and Utilization of Community Influence Through Exchange and Coordinative Relationships." Paper delivered at the annual meeting of the Southern Sociological Society in New Orleans, April 1969.

The above classification of roles has a significance for the communication of fire prevention and other types of messages. Clearly the "flow of communication" is not as simple a process as some have supposed. This fact suggests that change agents must not only work with local opinion leaders, but must be sure they select the right opinion leaders to work with, that is, those who have an interest in or are in accord with the innovation sought. In this regard, change agents can assume that communicator roles may be latent or inactive in the status-positions of the leaders, but they are always open to activation by the proper stimuli.

The Characteristics of Communicator Roles

Once types of communicator roles were identified and classified the next step was to analyze each role to determine its structural or sociological characteristics. Such characteristics provide clues as to how these roles might be articulated and bring about change in behavior. A classification worked out by Bertrand was used in this part of the study. This classification is based on the behavioral aspects of roles. Seven such dimensions can be recognized as follows:[16]

1. The "structural" distance of the role, or the number of system boundaries separating the position of one actor from other actors. In other words, how many different groups such as families, neighborhoods, and communities separate the two persons in interaction.
2. The range of reciprocality of the role, or the number of other persons activated by a single role played by a given person. In other words, the number of persons who are affected by the behavior of an actor.
3. The orientation of the role with respect to group boundaries, or whether all the actors are located within or without a given group. In other words, whether both persons in interaction belong to the same family or community, or whether one is an outsider.
4. The temporal span of the role, or how long a period of time the interaction between actors covers. In other words, how long the contact between individuals is maintained.
5. The permissive character of the role, or the tolerance range of behavior permitted in actor relationships. In other words, the leeway allowed in behavior, i.e., whether or not deviation in behavior is allowed.
6. The perceived importance of the role to group survival, or the importance attached to the role by actors. In other words, how serious the particular act is considered.
7. The clarity of the role, or the extent to which actors agree on the behavioral requirements of the role. In other words, how well the two actors understand what is expected from each other.

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[16] Alvin L. Bertrand, "A Structural Analysis of Differential Patterns of Social Relations: A Role Theory Perspective for Rural Sociology," *Rural Sociology*, Vol. 33, No. 4, December 1968, pp. 411-423.

Each type of role was tested on the above dimensions. The test was in terms of responses to questions regarding the way in which leaders behaved with regard to the issues outlined before. It was possible to do this since the characteristics of the role were inherent in the nature of their behavior. Also, relevant information was available for characterizing roles from the responses to questions of a personal-social nature posed to interviewees.

When measured in terms of the structural dimensions outlined above, it was discovered that there were indeed differences in the three types of roles identified. It was determined that the initiator type could be characterized as: (1) having a fourth order range of reciprocality (in that the role linked two or more complex organizations and various neighborhood groups); (2) being unilateral (in that it was reciprocal to only one type of alter-role); (3) being interorganizational (in that the two actors were not members of the same neighborhood groups); (4) having a short period of activity; (5) having a wide tolerance range (in that there was little prescription of norms); (6) being of great perceived importance (in that the "right" behavior was a driving concern of the actors); and (7) being relatively abstract in nature (in that the role was played by intuition rather than according to established patterns).

By comparison, the legitimizer type of communicator role had the characteristics of: (1) being multilateral (that is, reciprocal to two or more roles in the same group setting); (2) having a third order range (in that two groups were linked, a legitimizer-opinion leader group and initiator-legitimizer interstitial groups); (3) being extramural (in that elemental group but not organizational boundaries had to be crossed to fulfill role requirements); (4) being of intermediate duration; (5) being of great importance (only matters of some concern were worthy of legitimization); (6) being implicitly clear (in that the norms of validation, while not explicit, do imply a degree of clarity).

In final contrast, the diffuser type of communicator role was determined to have characteristics of: (1) a second order range (that is, only reciprocal to alters within the same elemental group); (2) being omnilateral (that is, reciprocal to all alters within a group); (3) being intramural (that is, played solely within a group); (4) having extended periods of activity (in that there was possibility of more or less constant interaction with one or another alter on the issue); (5) having a small range of tolerance (in that concrete feelings and behavior had been legitimized as correct and right); (6) being of great importance (again, only matters of concern were worthy of diffusion); (7) being explicit in nature (in that the behavioral implications of the message communicated were quite clear in meaning relative to future behavior of members of the group).

The structural characteristics of the role played by opinion leaders are shown in Table 2. These characteristics were determined by responses to questions included in the questionnaire administered.

Each of the 29 leaders was classified according to the communicator role most often identified with him. Of the 29 leaders, nine were determined to be initiators, as well as diffusers and legitimizers (ap-

TABLE 2.—Characteristics of the Communication Roles Played by Opinion Leaders

	Types of Communicator Roles		
Structural Dimension	Initiator	Legitimizer	Diffuser
Structural distance	4th Order (from family to another community)	3rd Order (from family to local community)	2nd Order (from family to neighborhood)
Range of reciprocality	Multilateral (several actors in group involved)	Multilateral	Omnilateral (all actors in group involved)
Orientation with respect to group boundaries	Interorganizational	Extramural	Intramural
The temporal span of roles	Short period of activity	Intermediate period of activity	Extended period of activity
Permissive vs mandatory behavior	Wide tolerance	Intermediate tolerance	Small tolerance
Perceived importance to group survival	Great importance	Great importance	Great importance
Clarity of norms	Relatively abstract	Implicitly clear	Explicitly clear

proximately one-third), nine were grouped as legitimizers plus diffusers, and 11 were categorized as only diffusers.

The determination of the variant characteristics of different classes of communicator roles has implications for those who would bring change to local communities. Obviously, initiator roles require and are played in a social setting different from those associated with legitimizer and diffuser roles. The former are played in a more open sophisticated milieu than are the latter. The players of these roles have contacts and are familiar with outside sources of information. Action agents should therefore look for leaders who circulate and have contacts outside their local areas, when seeking someone to initiate a fire prevention or other message. The intimate setting of the diffuser role suggests that those who play it have little outside contact.

The Personal-Social Characteristics of Opinion Leaders

The previous discussion made it clear that opinion leaders played important communicator roles in local areas. It was also brought out that the roles played were of distinct types which could be classified in such a way as to predict the setting in which they would be played. The purpose of the discussion which follows is to shed more light on the leaders who play such an important part in the affairs of a given community. In this way, it can be determined what, if anything, separates leaders from non-leaders and how leaders might best be approached by forest fire control agents and others. Table 3 was prepared to show comparison between leaders and non-leaders in the study community.

Social Participation Scores of Opinion Leaders

The measure of social participation used in this study was the extent of an individual's voluntary participation in formal organizations. Such participation was considered to be important because voluntary associations provide opportunity for social contacts as well as serve as channels for informal communications.

A modified form of Chapin's social participation scale was used to measure the degree of a person's participation in voluntary organizations. The respondents were asked to give by name the organizations with which they were affiliated.[17] The three components used in the scale were (1) member, (2) attendance, and (3) office position or committee member. Participation scores were computed by counting each component part of the scale as 1. Then, the score for each organization was added to the other organization scores to derive the final social participation score.

The level of social participation reported by opinion leaders indicated most of them were not greatly involved in community organizations. However, by comparison with non-leaders, they were more active in community affairs. The data in Table 3 shows the participation scores of leaders and non-leaders in the study area. More than three-fifths of the leaders scored less than 10. By contrast, approximately 90 per cent of the non-leaders scored this low. Close to one-fifth of the leaders scored as high as 15 points, while just about two of every 100 non-leaders scored this high. The above findings indicate that opinion leaders are more active in local organizations than the average person. However, their relatively low level of participation suggests that existing formal organizations may not be the best way to reach them. This conclusion has implications for action agencies. The agents of the latter may well find it more effective to concentrate on contacts with people through means other than existing voluntary associations.

Income of Opinion Leaders

Income, as the term is used here, refers to the total income received during the year preceding the interview. This included net farm income, non-farm income, spouse's income, and income from all other sources. Information related to income was obtained via the questionnaires completed for the leaders and non-leaders in the study locale. Eight of the 29 opinion leaders would not reveal their income to the interviewers.

The distribution of the leaders reporting their income revealed that a large proportion of them by comparison with non-leaders had incomes

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[17] According to Chapin an organization means "some active and organized grouping, usually but not necessarily in the community or neighborhood of residence . . . ." See: *Social Participation Scale*, Minneapolis, University of Minnesota Press, 1953.

TABLE 3.—Selected Personal-Social Characteristics of Opinion Leaders and Non-Leaders

Selected Personal-Social Characteristics	Leaders (N=29)	Non-Leaders (N=201)
	Per Cent	*Per Cent*
Age		
Under 30 years	0.0	9.9
30-39	10.3	17.4
40-49	27.6	21.9
50-59	24.1	19.4
60, over	38.0	31.4
Length of Residence		
Less than 1 year	0.0	7.4
1-2	0.0	6.0
3-5	3.4	14.9
6-10	3.4	8.0
More than 10	93.2	63.7
Social Participation Score		
0	0.0	16.9
1-4	31.0	50.2
5-9	31.0	28.8
10-14	20.7	2.3
15-19	10.3	.9
20, over	7.0	.9
Education		
Under 8 years	0.0	17.9
8	13.8	12.4
9-11	31.0	23.9
12	31.0	26.9
13, more	24.2	18.9
Income		
Less than $2,000	6.9	21.6
$2,000-$2,999	6.9	10.4
$3,000-$4,999	3.4	12.9
$5,000-$6,999	10.3	20.8
$7,000-over	44.9	19.4
No information	27.6	14.9

of $5,000 or more. This indicates that leaders are likely to be the more successful members of a community. However, despite the generally high incomes of opinion leaders (by local standards) about one out of every seven of them reported family incomes of less than $3,000. Yet, by comparison, three of every 10 non-leaders had incomes less than $3,000.

Age of Opinion Leaders

Age is regarded as an important sociopsychological and sociological factor and is often related to leadership.[18] Table 3 presents the age distribution of the opinion leaders identified. These leaders' mean age was determined to be 55 years, as compared with 51 for non-leaders. Only 10 per cent of them were as young as 30 to 39 years and none of them were under 30 years of age. Almost one out of five non-leaders was between 30 and 39 and 10 per cent of them were less than 30. Approximately two out of every five of the leaders were 60 years old or older, but less than one-third of the non-leaders were this old. It can be concluded from this pattern of age distribution that age does, in fact, play a part in leadership.

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[18] Ralph M. Stodgill, "Personal Factors Associated With Leadership: A Survey of the Literature," *Journal of Psychology*, XXV (January 1948), pp. 35-71.

Education of Opinion Leaders

In the present study, the number of years of formal schooling completed was used as a measure of education for the opinion leader. More than half (55 per cent) of them reported 12 or more years of schooling. Just 45 per cent of the non-leaders had this much schooling. Only 14 per cent of the leaders had completed as little as eight years of education, but 30 per cent of the non-leaders had not gone beyond the eighth grade. For the most part, the opinion leaders were better educated than the non-leaders. This fact, although expected, has implications for the roles they play.

Length of Residence of Opinion Leaders

Length of residence was another characteristic of the leaders that was considered important. Ninety per cent of the local opinion leaders had lived in the study area for 10 or more years. However, only nine were life-long residents. Only two of the 29 leaders had been residents in the local area less than 10 years. By comparison, almost two-thirds of the non-leaders had lived at least 10 years in their present locality. Just 13 per cent of them were relative newcomers, that is, residents of the neighborhood for three years or less.

Other Characteristics of Opinion Leaders

Other personal-social characteristics of opinion leaders were determined by the interviews made, although no comparisons with non-leaders are available. Among these were their occupation, number of acres of land operated, acres of timber owned, and number of cattle owned.

The occupation of leaders was classified into three categories on the basis of a social prestige scale. The high prestige occupational category included professionals, managers, and small business owners. The middle occupational group included persons in sales or clerical work and craftsmen or foremen. Semi-skilled and unskilled workers were classed as belonging to the lowest prestige occupational class.

The occupation prestige ranking of leaders is presented in Table 4. It may be seen that more than two-fifths of them were employed in the

TABLE 4.—Prestige of Occupations of Opinion Leaders

Occupational Classification	Number	Per Cent
High	13	44.8
Middle	10	34.5
Low	6	20.7
Total	29	100.0

high prestige occupations. Only six leaders were classified in the lowest prestige occupations. Most of the leaders maintained employment outside of the neighborhood area. It was also noted that most of the leaders' primary duties at work were oriented toward people rather than things.

Land ownership was regarded as another important characteristic of opinion leaders. As shown in Table 5 only two did not own land, and both of these were ministers. Half of the remaining number owned 101 or more acres of land. Approximately one out of every five owned over 200 acres.

Eighty-five per cent of the local leaders owning land reported some timber on their holdings. The mean number of acres of timber reported was 82.2. The amount of land in timber ranged from 8 to 1,400 acres. Further analysis of the data revealed that there was a strong positive relationship between the number of acres and the amount of land in timber. That is, as the number of land acres increased, the number of acres devoted to timber increased.

Some two-thirds of the leaders indicated they owned cattle. Eight reported having no cattle, 17 said they had less than 50 head of livestock, and two reported owning 50 or more head.

TABLE 5.—Land Ownership by Opinion Leaders

Size of Holdings	Number	Per Cent
None	2	6.9
1-50 acres	7	24.1
51-100 acres	7	24.1
101-200 acres	8	27.6
201 or more acres	5	17.3
Total	29	100.0

The Relationship of Communication Roles to Personal-Social Characteristics

It was considered important to determine if the leaders playing a particular combination of communication roles differed from other leaders in personal-social characteristics. The small numbers in each group necessitated caution in the interpretation of the data. Nevertheless, it was possible to make case observations and to test for significance in the differences noted.

In terms of social participation scores, leaders playing initiator as well as other roles appeared to be more involved in community affairs. That is, more of them had scores of 10 or above. Those playing both legitimizer and diffuser roles ranked second in this respect, while those playing only the diffuser role ranked last. Actually no leader identified as only a diffuser scored as high as 15 points, although three initiators and two legitimizers scored at this level.

Age was also found to vary with the type of communicator role played by the leaders. Over half of the initiators were below the age of 50 years while only one-third of the legitimizers and just over one-fourth of the diffusers fell in this age category. In contrast, only four initiators were over 60 years of age, but six legitimizers and six diffusers were in this age range.

The educational attainment of leaders varied less than was true for most of their characteristics. For example, about the same number of leaders in each type of communicator role group had obtained 12 or more years of schooling. The only difference noted was in those attending or not attending college. No leader playing a diffuser role had attended college, while one-third of the initiators and more than two-fifths of the legitimizers had schooling beyond high school. All of the initiators had at least nine years of schooling, but two legitimizers and two diffusers had completed eight or less years of education.

The length of residence reported by leaders appeared to vary with type of communicator role played. For example, all of the legitimizers and diffusers had lived in the study community for 10 or more years. However, two of the nine initiators had resided in the community for less than 10 years.

The pattern of relationship between the personal-social characteristics of leaders and their communicator roles is not too clear from the findings of the study. However, there is some evidence that initiators, legitimizers, and diffusers differ in their characteristics.

Opinion Leaders' Feelings About Forests and Forest Fires

One of the major objectives of the study was to determine the feelings and opinion of leaders about forests and woods burning. Toward this end, each of the leaders interviewed was asked a series of questions. Non-leaders were queried on the same points, so that comparisons might be made. The findings of this part of the study are presented below.

Opinion Regarding the Seriousness of Forest Fires

Respondents were asked if they considered forest fires a serious problem in the local community. In response to this question only 12 per cent of all the interviewees (leaders and non-leaders) said that the forest fire problem was an extremely serious matter. In contrast, more than 70 per cent implied by their answers that they did not feel the problem was serious. When the respondents were divided into leadership and non-leadership groups, it was discovered that a larger relative number of the former considered forest fires to be a serious problem.

TABLE 6.—Leaders' and Non-Leaders' Opinions Toward the Seriousness of the Forest Fire Problem in the Local Community

Opinion Statement	Leaders (N=29)	Non-Leaders (N=201)
	Per Cent	*Per Cent*
A very serious matter	17.2	11.4
Moderately serious	24.1	14.4
Not very serious	27.6	50.2
Not serious at all	31.1	24.0
Total	100.0	100.0

Table 6 reveals that over two-fifths of the leaders felt there was some reason to be alarmed about woods burning. Just over one-fourth of the non-leaders expressed the same feeling. This difference is not statistically significant, but does suggest that leaders are more aware of fire as a problem than the average local resident.

It was considered worthwhile to ask the respondents whether or not they felt that the number of forest fires in the area could be reduced. (See Table 7.) The most frequent answer given was that fires could be reduced to some extent. Interestingly, more than one-third of the leaders felt woods burning could be reduced quite a bit, as contrasted with about one-fifth of the non-leaders. On the other hand, almost one-fourth of the non-leaders felt the fires could not be reduced, while only approximately one-seventh of the leaders expressed such a pessimistic view.

Again, it appears that leaders have the more informed view. This finding provides some basis for optimism with regard to programs channelled through opinion leaders.

TABLE 7.—Leaders' and Non-Leaders' Opinions Toward Reducing the Number of Fires in the Local Community

Opinion Statement	Leaders (N=29)	Non-Leaders (N=201)
	Per Cent	*Per Cent*
Quite a bit	34.4	20.4
Somewhat	50.7	53.3
Not at all	14.9	24.3
No answer	0.0	2.0
Total	100.0	100.0

General Orientation to Forest Resources

It was considered appropriate to attempt an overall appraisal of informants' views toward forest resources. In order to do this, a six-item Guttman scale was developed.[19] The agree-disagree response items which were scaled included the following.

1. You don't have to worry about the woods because nature will always take care of the trees.
2. The future of the area economy lies largely in the development of forests.
3. Firing the woods is an established custom that should not be regulated by law.
4. Firing the woods doesn't really get rid of bugs and snakes and other pests.
5. Most of the timberland around here looks all grown up because it isn't burned often enough.
6. Grazing is a lot better when the land is burned off every year.

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[19] This scale was derived from the original set of items on the basis of a coefficient of reproducibility of 0.905. For a description of the Guttman scale, see S. A. Stouffer *et al., Measurement and Prediction,* New York: John Wiley and Sons, Inc., 1950, Chapter 3.

By means of this scale, it was possible to analyze the interviewers' responses to several items at the same time and rank them according to scale scores. Those with the lowest scores were considered most favorably oriented toward the forests; those with the highest scores were considered most unfavorably oriented. An individual with a high score, for example, felt: that firing the woods should not be regulated by law; that the woods didn't need any special care; that the future of the area economy did not lie in the development of forests; that firing the woods got rid of bugs, snakes, and other pests; that the local timberland looked all grown up because it was not burned enough; and that grazing was better when the land was burned every year.

Both local opinion leaders and non-leaders in general had high scores on the scale. This meant that attitudes toward the woods and forest fire prevention are relatively unfavorable. This pattern of responses may help explain other behavior patterns. There is no doubt that it is related to the high incendiary rate. It also is an indication that many feelings about fire are deep-seated and will be difficult to change.

The only conclusion which can be drawn from the above finding is that education alone is not the key to solution of the forest fire problem. The latter was evident in the respondents' answers to questions regarding the availability of fire prevention information. More than 85 per cent of the interviewees revealed that educational material about the woods was readily available to them. In addition, two out of every three respondents indicated that they had heard some kind of fire prevention message in the last six months. However, little evidence was found to indicate such exposure had affected the fire occurrence rate. In fact, an increase in the fire occurrence rate was apparent.

Summary and Implications

This study was undertaken to shed light on the problem of communicating fire prevention messages effectively. Specifically, an attempt was made to: (1) Identify local community influentials as opinion leaders in a high incendiary community; (2) determine whether or not these leaders played communicator roles within their localities; (3) ascertain the nature of communicator roles played by leaders, if such roles were indeed found; (4) determine the personal-social characteristics of leaders, and (5) determine the feelings of leaders about forests and forest fires.

The findings of the investigation may be summarized as follows:

1. Opinion leaders can be readily identified and located in rural communities.

2. Community opinion leaders definitely play communicator roles which have relevance for fire prevention programs.

3. The communicator roles played by local opinion leaders are of different types and each type is played in a different setting. Initiator roles played by local leaders serve to link local area with the outside. They serve as the port of entry for new ideas and ways. Legitimizer roles serve to validate and reinforce the worthiness or unworthiness

of the innovation to local persons. Diffuser roles are the vehicle through which the validated message is disseminated to the rank and file of community membership.

4. Initiator roles are most likely to be played in a *gesellschaft* or impersonal setting, where interaction is not necessarily based on intimate face to face association. Diffuser roles, by contrast, are most often played in *gemeinschaft* or primary group settings. Legitimizer roles are intermediate in terms of the social relations within which they are expressed.

5. Local opinion leaders, in the community studied, were likely to be older, to be better educated, to participate more in community organizations, to have larger incomes, and to own more land than the average head of a household. Opinion leaders were also in fairly prestigious occupations, and many of them worked away from home. They also had resided in their areas for a considerable length of time on the average.

6. There is not too much relationship between the social participation, age, education, and income of opinion leaders and the type of communication role they primarily play.

7. Opinion leaders exhibit more concern about forest fires and forest resources than non-leaders, but they are not greatly worried over such problems.

The above findings, when considered in the light of previous studies, have important implications for forest fire prevention. To date, programs of prevention have not been too successful, primarily because the proper vehicles for transmitting messages have not been utilized. This study indicates a need for a more precise identification of opinion leaders in terms of the communicator roles they could potentially play.

It is evident that the flow of communication is more complicated than has been indicated in previous studies. The discovery of different types of communicator roles makes this obvious. Since each different type of communicator role is played in the context of different reference groups, these roles must be and are different in their make-up. A message will only be successfully communicated when it is translated through all communicator roles. Wherever the message might originate, it must be introduced, legitimized, and diffused locally.

The study also provided clues for identifying local opinion leaders. It was determined, in addition, that these leaders tend to be more sophisticated than others in their area. They participate more, are wealthier, and have more education. Thus it could be expected that they would be more likely to listen to and understand a fire prevention message. However, they will have to be sold on its worth to them and their neighbors, and this calls for strategic approaches on the part of those interested in reducing forest fires.

There is no attempt in this study to provide exact guidelines as to how local opinion leaders can be recruited to sell fire prevention in their areas. However, the findings presented point strongly to the opinion leader as the key to the communication of effective fire prevention messages and provide some clues as to the ways and means by which these leaders might be recruited for such a role.

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RURAL YOUTH PLAN AHEAD

A Study of the Occupational, Educational, Residential and Marital Expectations of Rural Youth in Louisiana

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Rural Youth Plan Ahead

A Study of the Occupational, Educational, Residential And Marital Expectations of Rural Youth in Louisiana

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PEDRO F. HERNÁNDEZ AND J. STEVEN PICOU*

Introduction

Current social trends have precipitated many problems for the rural youth of America. Technological innovations have definitely curtailed occupational opportunities in rural areas for youth. Increased farm mechanization has been accompanied by an overall increase in the size of farms, which in turn has steadily reduced the labor demand in rural agricultural areas.[1] The fact that "only about 10 per cent of rural youth coming of age in the 1960's can look forward to farming for a living" indicates that these youths are confronted with serious problems concerning their occupational future.[2]

It is clear from the above that increasing numbers of rural youths are compelled to seek employment in urban areas. The implications of this fact are twofold. First, because more employment opportunities exist in the city, rural youth are compelled to migrate in order to secure jobs. Thus, unlike their urban counterparts, rural youth are confronted with the problem of leaving their community of orientation and adjusting to the urban environment. Second, within urban areas job opportunities in unskilled and semi-skilled occupations are rapidly declining. This means that, in order to be occupationally successful, rural youth must have the educational or vocational training necessary for placement in the professional, technical, and skilled occupations available in the city. In summary, occupational achievement for the vast majority of rural youths is contingent upon migration and educational plans.

Furthermore, the migration and educational plans of rural young people may cause other, more immediate, personal life goals to be modified. For example, plans for higher education may impinge on marital plans, causing the latter to be postponed until graduation from college.

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[1] For an example of the magnitude and implications of this trend in Louisiana, see: Adriaan K. Constandse, Pedro F. Hernández and Alvin L. Bertrand, *Some Implications of Increasing Farm Technology in Louisiana* (La. State Univ., Agr. Exp. Station, Bull. No. 628, August 1968), pp. 38-39.

[2] Samuel V. Merrick, "Perspective on Rural Youth Employment," Ruth C. Nash (editor), *Rural Youth in a Changing Environment* (Washington, D.C.: National Committee for Children and Youth, 1965), p. 103.

Rural youth in Louisiana are no exception to the problems discussed above. In Louisiana, from 1950 to 1966, cash receipts from farm marketing increased 65.9 per cent. In spite of this increase in output, the number of hired farm workers in Louisiana decreased from 68,000 in 1950 to 39,000 in 1966. In addition, total farm employment dropped from 213,000 to 107,000. (See Table 1.) Thus, in the state, over a recent 16-year period, technological advances stimulated a 65.9 per cent increase in farm marketing while concomitantly reducing total farm employment by 46.9 per cent. These figures indicate that many of Louisiana's rural youths will be forced to secure future employment in urban sectors of the state.

It is clear that Louisiana's rural youth are faced with making decisions that are crucial to their future. This report presents the major findings of a study on the occupational, educational, marital, and residential plans of a sample of black and white rural, high school seniors in Louisiana. It is hoped that the findings of this study will benefit those educators, educational administrators, and other persons within and outside the state of Louisiana concerned with the proper guidance of rural youth.

TABLE 1.—Farm Workers in Louisiana, 1950, 1960-66

Year	Total Workers	Family Workers	Hired Workers
	Thousands		
1950	213	145	68
1960	153	99	58
1961	156	92	64
1962	144	87	57
1963	141	82	59
1964	133	78	55
1965	121	71	50
1966	107	68	39

Source: United States Department of Agriculture, Agricultural Marketing Service, *Farm Labor*, 1951-1967.

Objectives of the Study

This study was undertaken to provide information on the social characteristics of seniors in rural high schools as well as their occupational, educational, residential, and marital plans. In other words, an attempt was made to discern what the rural youth of Louisiana expect to achieve in the future.

The specific objectives of this study were:

(1) To determine the future occupational plans of rural youth in Louisiana with particular reference to race and sex differences.

(2) To determine the future educational plans of rural youth in Louisiana with particular reference to race and sex differences.

(3) To determine the type of communities in which rural youth plan to settle, with particular reference to race and sex differences.

(4) To determine the future marital plans of rural youth, emphasizing desired ages for marriage and number of children expected, with particular reference to race and sex differences.

(5) To provide a better understanding of the plans Louisiana's rural youth have for their future.

Methodological Procedures

The major aim of the research design for this study was to get a representative sample of rural high school seniors in Louisiana. In order to accomplish this goal, schools were chosen by the use of a "stratified cluster" sampling design.[3] The state was first divided into four broad regions. Within each region the researchers constructed a list of all existing rural school zones. From this list 20 rural schools were randomly selected.

The data for this study were collected in the spring of 1968 through the group interview technique. All seniors who attended school on the days interviews were conducted were included in the sample. No attempt was made to contact seniors who were absent the day questionnaires were administered.

Altogether a total of 544 rural high school seniors were interviewed. By race, there were 330 white students and 214 black students included in the sample. Table 2 provides a breakdown of the sample by area, parish, number of students interviewed, and race.

Conceptual Frame of Reference

The conceptual frame of reference employed in this study is based on the "developmental model."[4] As children become older and more mature, their conceptions about future achievements become increasingly realistic. For example, the child of 8 or 9 has grandiose ideas about his future. That is, he wants to become a cowboy or an astronaut. At this time, his future projections are merely fantasies.

However, as the child grows older his plans for the future begin to assume "realistic" qualities. By the twelfth grade, definite plans for the future begin to crystalize. The youth must now seriously consider future vocational alternatives. Along with vocational choice, other decisions must be made, such as whether or not to continue his education, to marry, or to move out of the community in which he was raised.

From the perspective outlined above, it is apparent that the high school senior is a decision-maker. The decisions youths arrive at concerning their future are influenced by a number of sources. General societal values, family group influences, peer group influences, and the influence of the complex mass communication system in our society all condition to some extent the decisions made by youths. In addition to the influence of the norms and values of society and immediate ref-

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[3] Leslie Kish, "Selection of the Sample," Leon Festinger and Donald Katz (editors), *Research Methods in the Behaviorial Sciences* (New York: Holt, Rinehart and Winston, 1953), p. 220 ff.

[4] Eli Ginzberg, *et al.*, *Occupational Choice: An Approach to a General Theory* (New York: Columbia University Press, 1951), p. 16 ff.

TABLE 2.—Delineation of the Sample by Area, Parish, Number of Students, and Race

Area and Parish	Interviewed Seniors White	Black	Total
NORTHEAST			
West Carroll	23	–	
Richland	65	–	
Franklin	–	27	
Tensas	32	–	
LaSalle	18	–	
Total	138	27	165
NORTHWEST			
DeSoto (School No. 1)	–	67	
DeSoto (School No. 2)	12	–	
Natchitoches (School No. 1)	–	13	
Natchitoches (School No. 2)	21	–	
Natchitoches (School No. 3)	14	–	
Total	47	80	127
SOUTHWEST			
Avoyelles (School No. 1)	17	–	
Avoyelles (School No. 2)	–	57	
Avoyelles (School No. 3)	35	–	
Evangeline (School No. 1)	–	16	
Evangeline (School No. 2)	–	18	
Total	52	91	143
SOUTHEAST			
Pointe Coupee (School No. 1)	27	–	
Pointe Coupee (School No. 2)	30	–	
Ascension	19	–	
Livingston	17	–	
Plaquemines	–	16	
Total	93	16	109
TOTAL	330	214	544

erence groups, the decisions high school seniors make are also affected by numerous individuals who serve as personal role-models for future behavior patterns.

Furthermore, the high school youth's decisions regarding the future are influenced by his self-concept, which is a product of group experiences. The youth's evaluation of his own potentialities is an important factor in the formation of his future plans.[5]

Leading researchers on the status orientations of youth have noted that it is important to distinguish between the aspirations and the expectations that youth have for the future.[6] Aspirations are desires youth hold for the attainment of particular goals. On the other hand, an expectation is the youth's realistic anticipation of future achievement in a particular area. In other words, an aspiration is a desire, while an expectation is a realistic plan, which may or may not be desired.

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[5] Leona Tyler, *The Work of the Counselor* (New York: Appleton-Century-Crofts, 2nd. ed., 1961), p. 290.

[6] William P. Kuvlesky and Robert C. Bealer, "A Clarification of the Concept 'Occupational Choice'," *Rural Sociology*, 31 (September 1966), pp. 265-276.

For the purposes of this study, we are concerned solely with the future occupational, educational, migrational, and marital expectations (plans) of rural youth. The future plans of the rural youth presented on the following pages are viewed as a result of the various social influences that a youth experiences throughout maturation.

Background Characteristics of the Sample

As previously noted, a total of 544 rural black and white high school seniors residing in 16 Louisiana parishes made up the sample for this study. The median age for the white students was 17.4 years, while the median age for the black students was 17.6 years.

The vast majority of the rural youths involved in this study came from families of low socio-economic status. Table 3 shows that 46 per cent of the major wage earners in the families of the respondents were employed in either semi-skilled or unskilled occupations. Furthermore, 20 per cent of the major wage earners in the families of the respondents were unemployed at the time this study was conducted. A most surprising finding was that only one of the workers in these rural families was employed as a farm operator.

TABLE 3.—Occupational Categories of Major Wage Earners in Families of the Respondents

Occupational Category	Per Cent
Professional	5
Owner-manager	9
Clerical and sales	2
Skilled	16
Semi-skilled	26
Unskilled	21
Farm operator	1
Unemployed	20
Total	100

For purposes of analysis, the eight occupational categories in Table 3 were collapsed into three major occupational levels. It was found (Table 4) that approximately 7 out of 10 of the major money earners in the respondents' families were employed in lower class occupations.[7] Interestingly, of the 27 per cent of the major wage earners in the middle level, 16 per cent were employed in skilled occupations. Almost all of the individuals in the professional category were employed as primary or secondary school teachers.

Table 5 provides a picture of the educational levels of the respondents' parents by race. The vast majority of the parents of the respon-

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[7] The lower class occupational level includes those major money earners in the families of the respondents who were unemployed at the time this study was conducted.

TABLE 4.—Occupational Levels of Major Wage Earners in Families of the Respondents

Occupational Level	Per Cent
Upper	5
Middle	27
Lower	68
Total	100

dents were found to have only a high school education or less. It was also found that the educational attainment of the black students' parents was considerably lower than that of the parents of the white students. For example, 22 per cent of the fathers of white students had at least attended a college or trade school. In contrast, only 6 per cent of the fathers of black students had attained a similar level of education. In addition, 60 per cent of the black fathers and 38 per cent of the black mothers had gone no higher in school than the seventh grade.

TABLE 5.—Educational Levels of Respondents' Parents by Race

Educational Level Attained by Parent	White (N=274) Father	White (N=274) Mother	Negro (N=190) Father	Negro (N=190) Mother
	Per Cent			
Completed college and higher	8	9	3	7
Some college but not degree	10	6	3	4
Technical school	4	5	0	4
Completed high school	22	30	6	9
Grades 8-11	31	32	28	38
Grades 1-7	21	9	46	23
No school	4	9	14	15
Total	100	100	100	100

The families of the black students were found to be characterized by higher rates of instability than the families of the white students. Table 6 reveals that 86 per cent of the white students were members of a complete family system, whereas only 62 per cent of the black students were living in households which included both parents.

TABLE 6.—Marital Status of Respondents' Parents by Race

Marital Status	White (N=324)	Black (N=209)
	Per Cent	
Both alive, living together	86	62
Both alive, separated	2	16
Both alive, divorced	4	9
Father dead	5	9
Mother dead	3	4
Total	100	100

In summary, the analysis of the general background characteristics of the respondents' families indicated that most of the rural black and white students interviewed came from socially disadvantaged families. Very few of the respondents' parents had attained a high occupational or educational level. The majority of the major money earners in the families of the respondents held lower class occupations, and few of the respondents' parents had attained education beyond high school. Proportionately more black parents than white parents had low educational attainment. Black families were also found to be characterized by higher rates of instability or broken homes.

The Employment Problem: Occupational Plans Rural Youth Have for the Future

The decision to enter a specific occupation has many implications for a high school youth. For example, in order to become a doctor, a youth must continue his education beyond high school anywhere from eight to twelve years. Likewise, a decision to become a nurse, teacher, machinist, or professional athlete affects the nature of an individual's future social relationships and to a great extent determines his "social identity."

Furthermore, varying amounts of prestige and status are associated with different occupations. People tend to evaluate individuals on the basis of their occupational achievements. It is an observable fact in our society that a medical doctor is usually accorded more status than a truck driver.

Equally true is the fact that occupations differ in terms of financial rewards. It is common knowledge that a medical doctor usually has a considerably larger income than the truck driver. The skilled carpenter ordinarily is the recipient of a larger paycheck than the unskilled laborer.

In addition, it should be noted that the personal satisfaction and enjoyment an individual receives from his job is also an important consideration in the formation of the occupational plans by youth. Entrance into a "rewarding" occupation, whether it is a white collar or blue collar job, is very important for the proper social adjustment of the individual.

In this section the occupational plans of the black and white rural youths involved in this study will be analyzed. The occupations designated by the respondents were classified and ranked according to a modified version of the census scheme.[8] The occupational plans of the male and female respondents will be reported separately and racial comparisons made within both sex categories.

Table 7 shows that the occupational plans of the rural black and white males were very similar. The vast majority of all the male high school seniors anticipated entering either professional, semi-skilled, or skilled occupations. Approximately 3 out of every 10 males from each race category expected future employment in professional occupations.

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[8] The occupational ranking scheme employed in this study is similar to the classification method utilized by the United States Bureau of the Census. Modifications were made by combining similar occupational categories. This procedure was carried out in order to facilitate the analysis of the data.

TABLE 7.—Occupational Plans of Rural High School Senior Males by Race

Occupational Category	White Males (N=149)	Black Males (N=67)
	Per Cent	
Professional	30	31
Owner-manager	13	6
Glamour	3	5
Clerical and sales	2	8
Skilled	19	18
Semi-skilled	28	25
Unskilled	5	6
Farm operator	0	1
Total	100	100

Professional occupations chosen most frequently by the respondents were school teacher and engineer. Table 7 also reveals that 28 per cent of the male white students and 25 per cent of the male black students expected to hold future jobs in the semi-skilled occupational category. Most of the respondents in this category planned to be heavy equipment operators or plant workers.

It was also found that 19 per cent of the male white students planned to enter skilled occupations. Occupations such as auto mechanic and plumber were among those most frequently chosen. Indicative of current occupational trends was the finding that only one black male planned to work as a farm operator.

The occupational plans of the black and white females fell mainly into two categories. Table 8 reveals that 82 per cent of both the white and black females interviewed planned on securing employment in either professional or clerical and sales occupations. This finding is not considered unusual due to the fact that most job opportunities for females exist in these two categories.

Slightly more black females (48 per cent) than white females (40 per

TABLE 8.—Occupational Plans of Rural High School Senior Females by Race*

Occupational Category	White Females (N=115)	Black Females (N=105)
	Per Cent	
Professional	40	48
Owner-manager	1	5
Glamour	3	4
Clerical and sales	42	34
Skilled	12	11
Semi-skilled	2	1
Unskilled	2	1
Farm operator	0	0
Total	100	100

*Further exploration was done, in regard to occupational plans (expected employment), by collapsing the responses into two groups according to race.

The Kruskal-Wallis statistical test showed that there was a significant difference between races in their expectations: "H" statistic = 29.68, significant at 0.001 level of significance, for df = 3. This means that something in the fact of being white or black affected the various plans for occupation, which was not due to chance.

cent) planned on future professional occupations. Professional occupations most frequently chosen by all girls were school teacher and registered nurse. Forty-two per cent of the white females and 34 per cent of the black females anticipated work in clerical and sales occupation. Office secretary, typist, and stenographer were singled out by the respondents as the clerical and sales occupations anticipated most frequently.

The Problem of Employment Prerequisites: The Educational Plans Rural Youth Have for the Future

In modern society, education is seen as an intervening factor between man and employment. In order to secure financially rewarding, prestigious jobs, contemporary youth are faced with the problem of securing formal training, which often entails college and graduate study. It is becoming increasingly essential for youths planning to enter technical and skilled jobs to obtain formal vocational training.

The problem of educational attainment is a crucial one for disadvantaged rural youths. If a rural youth fails to receive a college degree or some type of formal vocational training, his chances for upward social mobility are seriously impaired. Joseph Kahl has cogently pointed out that a Bachelor's degree provides one with an admission ticket to middle class occupations.[9] This fact is of special importance to the rural youth who, more often than not, comes from a lower class family.

In this section the educational plans of the black and white rural students involved in this study will be analyzed. All students were asked to indicate whether they planned to quit high school immediately, complete high school, attend a vocational school, attend a junior college, graduate from a four-year college, or do graduate work. The educational plans of the respondents are reported in terms of racial comparisons for both sex categories.

It was found that 77 per cent of both the Negro and white males planned to continue their education in one form or another after high school. Table 9 reveals that 37 per cent of the white males and 30 per cent of the Negro males anticipated graduating from a four-year college or university. An additional 12 per cent of the whites and 17 per cent of the Negroes expected to complete graduate work in a chosen field. Thus, almost half of all the rural males interviewed planned to obtain at least one college degree. It is apparent that the rural males interviewed viewed educational achievement as an important factor in their future.

Twenty-six per cent of both the black and white males indicated that they planned some formal type of vocational training after high school. Most of these students undoubtedly plan on pursuing a skilled occupation in the future. Interestingly enough, approximately 2 out of every 10 of the white and black males planned no additional educational training beyond high school. Apparently these youths will be forced into

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[9] Joseph A. Kahl, *The American Class Structure* (New York: Rinehart and Company, Inc., 1967), pp. 276-278.

TABLE 9.—Educational Plans of Rural High School Senior Males by Race

Level of Educational Attainment Planned	White Males (N=167)	Black Males (N=91)
	Per Cent	
Graduate work	12	17
Graduate from college	37	30
Junior college	2	4
Business or vocational school	26	26
Complete high school	22	20
Quit high school immediately	1	3
Total	100	100

competition for rapidly disappearing unskilled occupations. The occupational future for these youths appears questionable in view of the occupational opportunities that exist today.

There was a noticeable difference between the educational plans of the white and black females involved in this study. Table 10 reveals that 28 per cent of the black females, in contrast with only 7 per cent of the white females, had plans to do graduate work in college. It was also found that more white girls (35 per cent) than black girls (21 per cent) expected to obtain a college degree. Generally, more black females (88 per cent) than white females (74 per cent) planned to receive some type of formal educational training after high school.

TABLE 10.—Educational Plans of Rural High School Senior Females by Race

Level of Educational Attainment Planned	White Females (N=157)	Negro Females (N=123)
	Per Cent	
Graduate work	7	28
Graduate from college	35	21
Junior college	3	11
Business or vocational school	29	28
Complete high school	25	10
Quit high school immediately	1	2
Total	100	100

The Migration Problem: The Future Residence Plans of Rural Youth

Donald J. Boque and Calvin L. Beale, among others, have noted that current rural-urban migration trends are characterized by a "rapid concentration of the majority of the nation's people into metropolitan areas."[10] Within the state of Louisiana, researchers have found that from 1950 to 1960 "there were high rates of net *in* migration for all age-race-sex groups" to urban areas and "high rates of net *out* migration for all such groups in rural areas."[11] Furthermore, every year many rural Negroes leave Louisiana, moving to large northern and West Coast cities.

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[10] Donald J. Boque and Calvin L. Beale, "Recent Population Trends in the United States and Their Causes," James H. Copp (editor), *Our Changing Rural Society* (Ames, Iowa: Iowa State University Press), p. 123.

Most of the people leave rural areas in order to secure better employment. Rural youth face the problem of diminishing employment opportunities within their local communities. If the young rural high school graduate is going to find employment, more often than not his only chance for getting a job is in a nearby urban area. Furthermore, rural youngsters who plan to get a college education realize that the top salaries in the business world are offered in the city.

However, it should be noted that individuals have personal values and preferences that go a long way in determining their future. An individual may value the rural environment so highly that he may decide against leaving his community of orientation, despite the occupational and financial advantages of the city. Accordingly, individuals may plan on residing in a small city or spreading, complex metropolis. In other words, a rural youth has many alternatives in selecting future residence. The choice made rests on the personal values and the desires and preferences of the individual.

Of the male high school seniors involved in this study, more blacks (62 per cent) than whites (52 per cent) planned to reside in cities (Table 11). The major difference between the residence plans of the black and the white males was that considerably more blacks (29 per cent) planned on living in large metropolitan areas than did whites (6 per cent). On the other hand, 46 per cent of the white males indicated that they planned on living in a small city, while only 33 per cent of the black males expected similar residences. Approximately 3 out of every 10 of the Negro and white students planned to reside in rural non-farm areas.

TABLE 11.—Residence Plans of Rural High School Senior Males by Race

Residence Plans	White Males (N=130)	Black Males (N=86)
	Per Cent	
Metropolitan area	6	29
Small city	46	33
Town or village	9	2
Open country, non-farm	30	29
Farm	9	7
Total	100	100

In Table 12 the residence plans of the respondents were collapsed into the general categories of rural and urban so that indications of future migration trends would be more obvious. It was found that ap-

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[11] Roger L. Buford, Alvin L. Bertrand and Walfrid J. Jokinen, *Louisiana's Human Resources, Part IV: Migration of Working Aged Population*, Bulletin No. 595, Louisiana State University, Agricultural Experiment Station, (May 1965), p. 9.

TABLE 12.—Rural-Urban Classification of the Residence Plans of Rural High School Senior Males by Race

Residence Plans	White Males (N=180)	Black Males (N=86)
	Per Cent	
Urban	61	64
Rural	39	36
Total	100	100

proximately 6 out of 10 of all the male rural students involved in this study planned to move to some type of urban area in the future. This finding indicates that rural males will probably still be leaving their community of orientation at substantial rates in the future.

Table 13 shows that substantially more black females (36 per cent) than white females (10 per cent) planned to live in large metropolitan areas. Most of the white females (80 per cent) planned to reside in small urban and rural non-farm areas, while most of the black females (84 per cent) anticipated living in large metropolitan and small urban areas.

TABLE 13.—Residence Plans of Rural High School Senior Females by Race

Residence Plans	White Females (N=148)	Black Females (N=118)
	Per Cent	
Metropolitan area	10	36
Small city	53	48
Town or village	1	1
Open country, non-farm	27	13
Farm	9	2
Total	100	100

By collapsing the data on the residence plans of the rural females into rural and urban categories, it was found that substantially more black females than white females planned on living in urban areas (Table 14). More than 8 out of 10 of all the Negro females anticipated residing in some type of urban area. However, the finding that 64 per cent of the white females planned to live in an urban setting is similar to the residence plans of the white and black males discussed above.

TABLE 14.—Rural-Urban Classification of the Residence Plans of Rural High School Senior Females by Race

Residence Plans	White Females (N=148)	Negro Females (N=118)
	Per Cent	
Urban	64	85
Rural	36	15
Total	100	100

The Problem of Getting Married and Having A Family: The Marital and Procreational Plans Rural Youth Have for the Future

All high school youth realize that someday they will probably get married and have children. However, the answer to the problems of exactly when to get married and how many children to have is contingent upon a number of other factors.

In contemporary society there is a tendency toward marriage at an early age. This fact creates a dilemma for young people who are planning to attend college. Should marriage be immediate or postponed until after graduation?

Furthermore, modern family planning methods bring to fore the problem of how many children are desirable for a family. Should the number of children be consistent with the financial resources of the parents? Just as important, how does one determine just what is an ideal ratio of income to number of children?

It is apparent that marital plans are affected by, and in turn, affect, the occupational and educational plans of high school youth. In this section of this report, an analysis of the ages rural youth consider desirable for marriage will be presented. In addition, an analysis of the number of children the respondents expect to have in their future families is included.

In Table 15 a comparison of the ages all respondents preferred for marriage is presented by race and sex categories. It was found that black males and females desired to put off marriage longer than their white counterparts. Slightly more than half of the black males (53 per cent) desired to get married after 25, while only 34 per cent of the white males had similar desires. White males generally preferred to get married between the ages 20 and 24. Both black and white males indicated that getting married prior to the twentieth birthday was undesirable.

Noticeable differences between black and white females were also found in the preferred ages for marriage (Table 15). White females tended to prefer marriage at an earlier age than their Negro counterparts. It was found that 20 per cent of the white females considered marriage prior to their twentieth birthday as desirable. In contrast, only 6 per cent of the black females held a similar preference. Furthermore,

TABLE 15.—Preferred Ages for Marriage of the Rural Senior High School Respondents by Race and Sex

	Males		Females	
Age	White (N=156)	Negro (N=85)	White (N=149)	Negro (N=115)
	Per Cent			
Below 20	6	2	20	7
20-24	60	45	74	63
25 and greater	34	53	6	30
Total	100	100	100	100

substantially more black girls (30 per cent) than white girls (6 per cent) preferred marriage after the age of 25. Overall, the vast majority of both the white and black female respondents considered marrying between the ages of 20 and 24 as ideal.

Table 16 presents a breakdown of number of children expected in the future families of the respondents by race and sex categories. The majority of all the students indicated that they planned on having from two to four children in the future. White and black males had relatively similar procreation plans, while white females appeared to expect slightly larger families than black females. For the female respondents, 17 per cent of the whites planned on having five or more children. In contrast, only 6 per cent of the black females anticipated having this many children. Furthermore, proportionately more black females (48 per cent) than white females (25 per cent) expressed plans for two or fewer children.

TABLE 16.—Number of Children Expected in the Future Families of the Rural Senior High School Respondents by Race and Sex

	Males		Females	
Number of Children Expected	White (N=167)	Negro (N=91)	White (N=157)	Negro (N=123)
	Per Cent			
None	9	6	7	6
One	3	3	3	3
Two	26	31	15	39
Three	27	10	20	18
Four	24	35	38	28
Five or more	12	15	17	6
Total	100	100	100	100

Goals and Values

Our expectations have to do with the goals and values we establish in our lives. A balanced perception of such goals and values has two complementary points of view. One is the point of view of the societal system, funneled and presented to individuals in the frame of family living and peer-group associations—the so-called "expected-self," that is, the image of the person as presented to him by the group. The other is the point of view of the individual, or the personal reaction to such an "expected-self."

An attempt to associate these two views is the exploration of things which may be perceived by the youngsters as being important in life. A question like this was posed to the interviewed persons, namely: "Rank these things (listed below) that most people look forward to in order of their importance to you."

The answer to such a question implies two or maybe three insights which seem to be extremely relevant. The first is the insight into the group opinion and perception of well-recognized American social values. Because of the emergence of contemporary youth crises and various youth movements, this insight may also be coupled with a need for revision of commonly accepted values and/or value-orientations which are still prevalent in sociological literature concerning American value-systems. Furthermore, an insight into a sort of projective test of personal value-orientations prevalent among the different relevant groups (by sex and race) can also be achieved. All this shows a higher degree of complexity in interpreting the findings of the survey.

Three findings are among the most revealing ones in a general perspective:

1. The almost overwhelming priority and concern for education among the youngsters, well above other worthy things of life.
2. The lower concern and importance of going into marriage and raising a family.
3. Finally, a decreasing concern for wealth and big money earnings among the youngsters, if compared with most of the well-known studies of societal value-orientations in America.

Wanted residence and material things, which ranked even lower than big money earnings, appear to confirm the last point. These three items, which particularly relate to what one could label "material comfort" in life (money, residence, and wealth), seem to call for a revision of cliches which are a commonplace in sociological literature of classes, education, and values, and also for more scientific literature on opinion sampling and exploration of youth crisis.

Table 17 provides an overview of the elementary scaling of perceived goals.

TABLE 17.—Louisiana Rural High School Seniors: Their Scale of Preferences for Things They Consider Important in Life

	Scale of Preferences			
	White		Black	
Item	Male	Female	Male	Female
Enjoy free time	1	2	2	4
Education	2	1	1	1
To have the job they want	3	3	3	2
Money	4	6	5	3
To possess many things	6	5	5	6
To live where they please	5	4	4	5
To have a family and children	7	7	6(=7)	7

Summary of Findings

This study has concentrated on four problem areas in which rural youths are forced to make crucial decisions regarding their future. Knowledge of this sort is important because the disadvantaged social position of the vast majority of rural youths necessitates some understanding of their future plans. The findings of this study in regard to the future occupational, educational, residential, and marital plans of rural youth in Louisiana may be summarized as follows:

1. The majority of the male high school seniors planned to enter

either "professional," "semi-skilled," or "skilled" occupations. Professional occupations were chosen most often by the male respondents. Approximately 3 out of 10 of both the black and white high school seniors anticipated future employment as professionals. The professional occupations chosen most often by the respondents were teacher and engineer, respectively. Both the black and white males involved in this study had relatively similar occupational plans for the future.

2. The future occupational plans of the female high school seniors interviewed fell mainly into two occupational categories. Four out of every 10 of the white and black females planned to enter "professional" occupations. Professional occupations chosen most frequently were teacher and registered nurse, respectively. Office secretary and typist were most frequently selected as preferable occupations in the "clerical and sales" category. More than 3 out of 10 respondents planned on "clerical and sales" jobs.

3. The educational plans of the black and white rural high school seniors were found to be similar. Slightly less than 7 out of every 10 of the male respondents planned to continue their education in some manner after high school. Almost half of all the students expected to obtain at least one college degree in the future.

4. Black and white females were found to have somewhat different plans for their educational future. Proportionately more black females (88 per cent) than white females (74 per cent) planned additional educational training after high school. Furthermore, more black females (28 per cent) planned to attend graduate school than white females (7 per cent). However, it was found that more white females than black females planned on just graduating from a four-year college.

5. Overall, black and white males were found to have similar residence plans for the future. Slightly more than 6 out of every 10 of the black and white students expected to reside in an urban area. However, black males were found to be more predisposed toward living in large metropolitan areas, while white males generally expected to reside in smaller urban areas. Of the rural males planning on remaining in rural areas, approximately three-fourths planned non-farm residences. Only 9 per cent of the white males and 7 per cent of the black males anticipated farm residences for the future.

6. Substantially more black females (85 per cent) than white females (64 per cent) planned on residing in urban areas. Black females also planned on living in large metropolitan areas in greater numbers than did white females. White females displayed a greater tendency for planning on residing in rural farm and non-farm areas than did their Negro counterparts.

7. Proportionately more black males than white males desired to get married at an older age. More than half of all black students interviewed preferred to marry at the age of 25 or over. Only one-third of the white males held similar age preferences for marriage. The majority of the white males indicated that marriage was desirable between the ages of

20 and 24. Marriage before 20 years of age was desired by approximately 5 per cent of all males interviewed.

8. The vast majority of the white and black females indicated that marriage was desirable between the ages of 20 and 24. However, there was a distinct tendency for white females to desire marriage at an earlier age than did black females. Twenty per cent of the white females, in contrast with 7 per cent of the black females, thought marriage was desirable before the age of 20. On the other hand, 30 per cent of the black females, opposed to 6 per cent of the white females, desired to be married at the age of 25 or later.

9. The majority of both the black and white male respondents expected to have from two to four children in their future families. Approximately only 1 out of every 10 males expected to have as many as five or more children. Similarly, approximately only 1 out of 10 males anticipated having only one child or none in the future.

10. Proportionately more white females expected to have five or more children, while proportionately more black females anticipated having only two children.

11. The youngsters showed overwhelming concern for education and less concern for big earnings, and the possession of material things, in contrast to many of the accepted "cliches" of American goal orientations commonly noted in social literature. Still less concern was shown for founding a family and having children, if compared with other things. All this demands further exploration in regard to the present crisis of younger generations in America.

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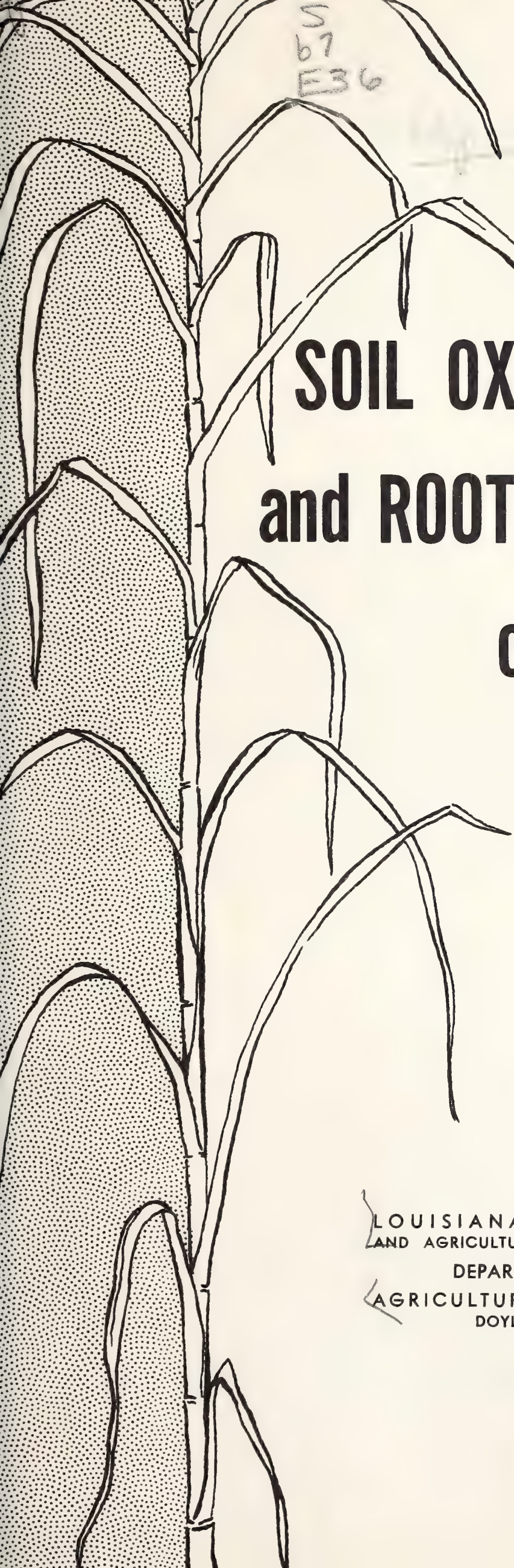
Bulletin No. 641



SOIL OXYGEN CONTENT and ROOT DEVELOPMENT of SUGAR CANE

W. H. Patrick, Jr., F. T. Turner and
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AND AGRICULTURAL AND MECHANICAL COLLEGE
DEPARTMENT OF AGRONOMY
AGRICULTURAL EXPERIMENT STATION
DOYLE CHAMBERS, DIRECTOR

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Soil Oxygen Content And Root Development of Sugar Cane[1]

W. H. PATRICK, JR., F. T. TURNER, AND R. D. DELAUNE[2]

Restricted aeration is a common occurrence in many of the poorly drained Mississippi River Alluvial soils in Louisiana. Such conditions as high rainfall, low runoff, soil compaction, high clay content, poor soil structure, and high water table create unfavorable porosity and aeration relationships in the soil which apparently limit root development and crop productivity.

These limitations are especially severe in the sugar cane area of South Louisiana where cane is grown on low-lying natural levees of the present or abandoned Mississippi River channels. It is assumed that root development in these soils is limited by restricted oxygen content caused by poor surface drainage and poor internal drainage in the soil profile, although no actual data are available to establish this fact. The investigation reported here had three objectives: (1) to develop a system for sampling soil air and determining its oxygen content in a 4-foot soil profile, (2) to measure the oxygen content in the profile during the growing season, and (3) to determine whether the soil oxygen content affects the distribution of sugar cane roots.

EXPERIMENTAL PROCEDURE

Representative Mississippi River Alluvial soils in Terrebonne Parish (Commerce, Mhoon, and Sharkey series) and St. Mary Parish (Cypremort, Baldwin, and Iberia series) were selected for this study. Transects from the natural levee to the back swamp were made to provide sampling sites differing in elevation, texture, and internal drainage. Commerce soils are usually found on the crests of the natural levees of the present and abandoned channels of the Mississippi River, Mhoon soils at lower elevations on the natural levees, and Sharkey soils at still lower elevations near the back swamp. The same positional relationship exists for the Cypremort, Baldwin, and Iberia soils, except that these soils occur on sediments deposited about 2,000 years earlier. The Sharkey and Iberia soils are usually highest in clay content and have the poorest internal drainage.

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[1] This work was supported in part by the Soil and Water Conservation Research Division, Agricultural Research Service, United States Department of Agriculture.

[2] Professor and Associates, respectively, Department of Agronomy.

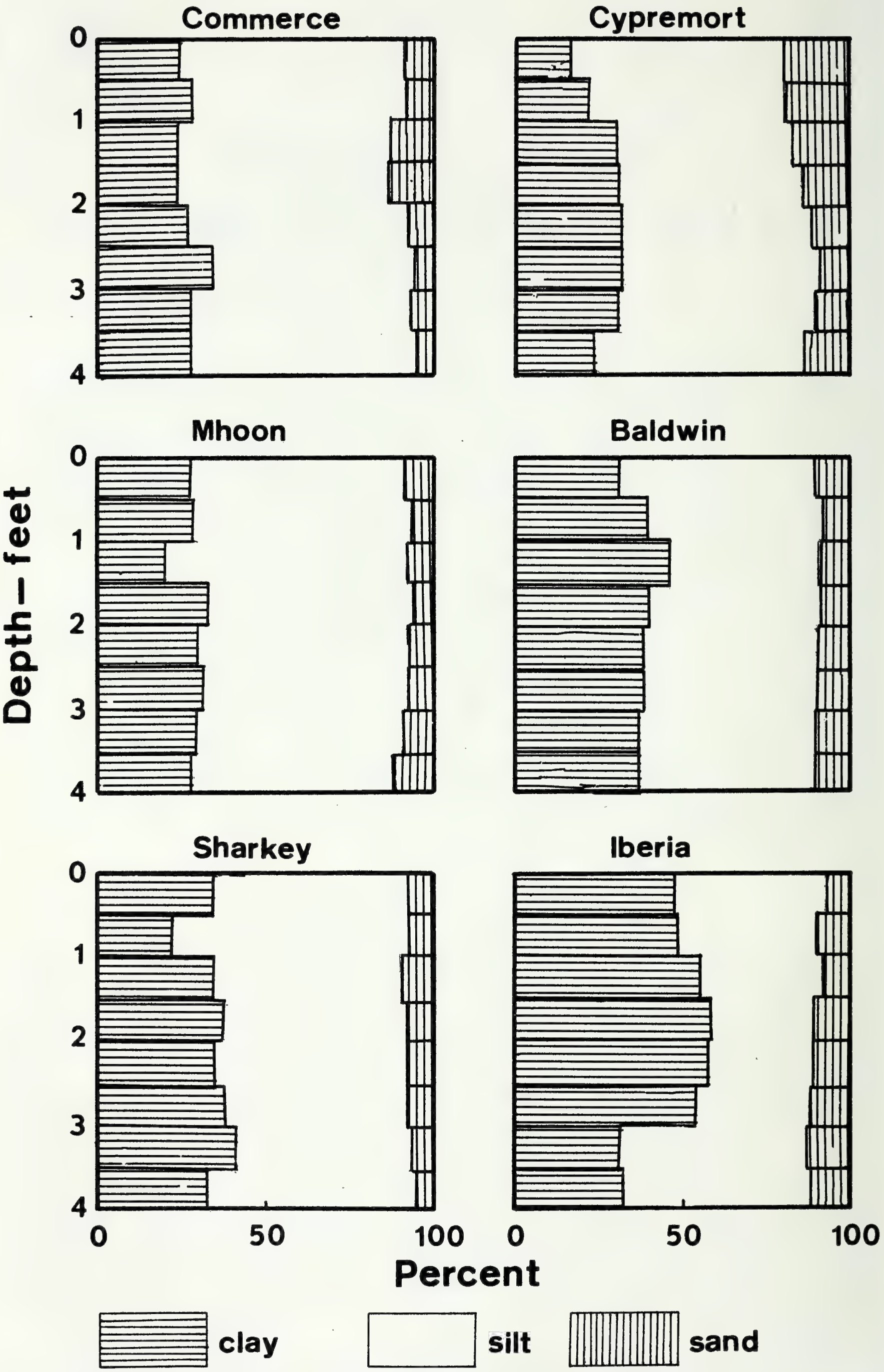

FIGURE 1.—Particle size distribution of the six soils. Each profile represents an average of three locations.

For each of the six soils, three apparently uniform sampling sites 100 to 200 feet apart were selected. This provided a total of 18 profile sites. All sites were located in areas of plant cane so that no roots from a previous year's crop would be measured. The average distribution of sand, silt, and clay throughout the profiles is shown in Figure 1. The Cypremort, Baldwin, and Iberia soils showed an increase in clay content going from the natural levee toward the back swamp, but there was less difference in clay content among the Commerce, Mhoon, and Sharkey soils than is usually encountered for these three soils.

Two methods were developed for sampling and analyzing soil air for oxygen content. One method consisted of a special air sampling probe which could be inserted into the soil to various depths to withdraw air samples for oxygen analysis. In the other method small air reservoirs were established in the soil at various depths from which air could be drawn for oxygen analysis. In both methods the air was drawn directly into a specially constructed cell containing a Clark-type, membrane-covered polarographic oxygen electrode. A battery-operated oxygen analyzer (Yellow Spring Model 51) was used for analysis of oxygen.

A Special Probe for Soil Oxygen Determination

The probe designed and constructed to sample and measure oxygen content of the air at various depths in the soil is illustrated in Figure 2. It consisted of a 4-foot-long, thick-wall stainless steel tube of ½ inch outside diameter and 1/16 inch inside diameter. A ⅜-inch-diameter, bullet-shaped point (slightly smaller in cross section than the tube) was fitted on the end of the probe. In a notched section of the probe directly behind the shoulder of the point were twelve 1-millimeter-diameter openings. The probe was pushed into the soil to the desired depth, and the recessed area behind the tip formed an open chamber in the soil which was sealed from the atmosphere by the larger shoulder of the shaft of the probe. Soil air was drawn through the probe with a suction bulb containing a one-way valve. The oxygen electrode was in a specially machined stainless steel cell on top of the probe and positioned so that the membrane was in the path of the soil air going through the probe. Because of the small internal volume of the sample tube and oxygen analyzer cell only a small volume of air was required for analysis. Figure 3 shows the oxygen concentration in the analyzer cell as various amounts of air of a known composition were drawn into the cell. Approximately 15 milliliters of air from the soil were required to displace the existing air in the system and provide an accurate reading.

The probe worked well for coarse-textured soils, from which air was readily drawn into the probe. It did not work well in fine-textured soils or in soils that were nearly saturated with water because of the difficulty of withdrawing air from the soil without applying a fairly high vacuum. The vacuum affected the calibration of the oxygen analyzer.

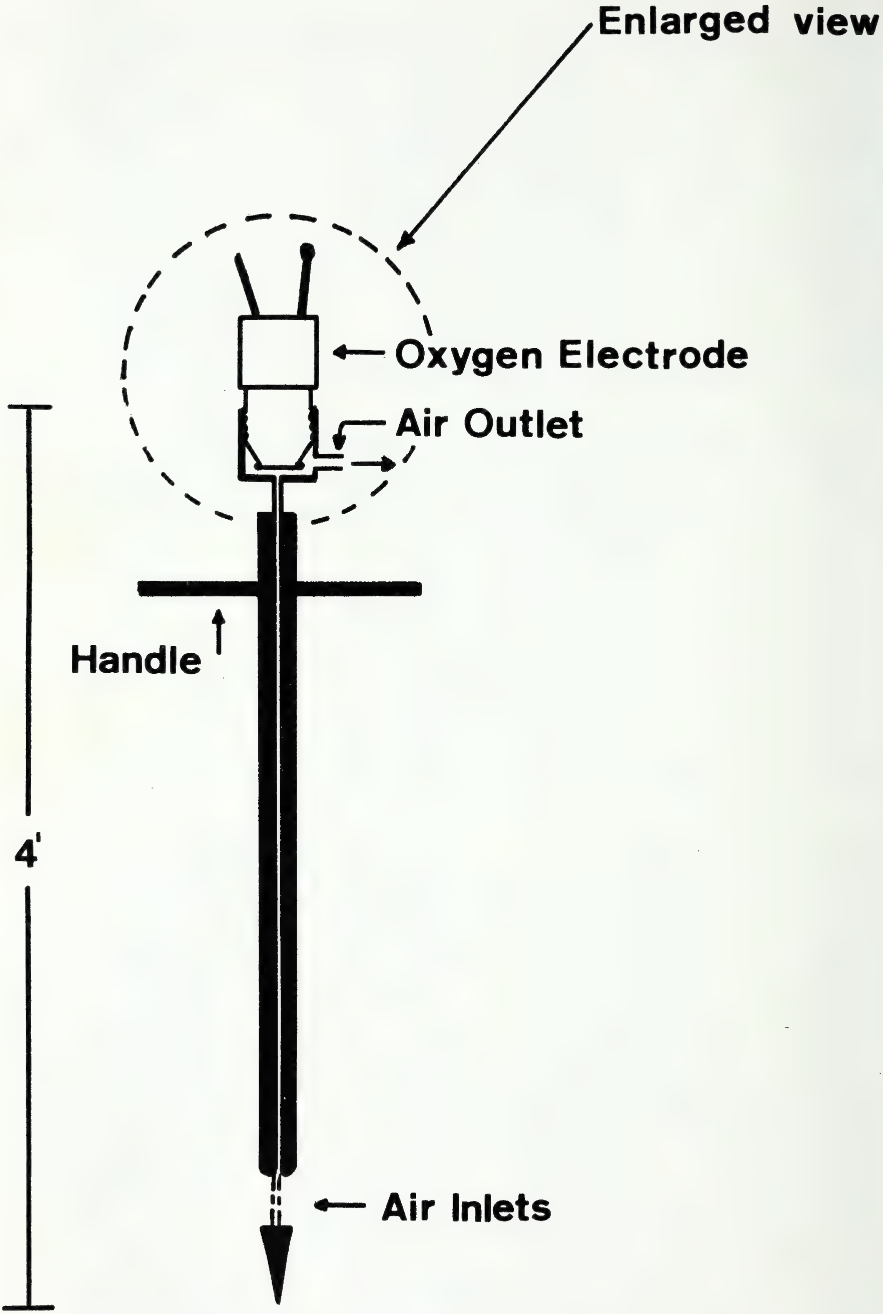

FIGURE 2.—The probe and analyzer cell used for soil oxygen measurement. An enlarged view of the analyzer cell is shown.

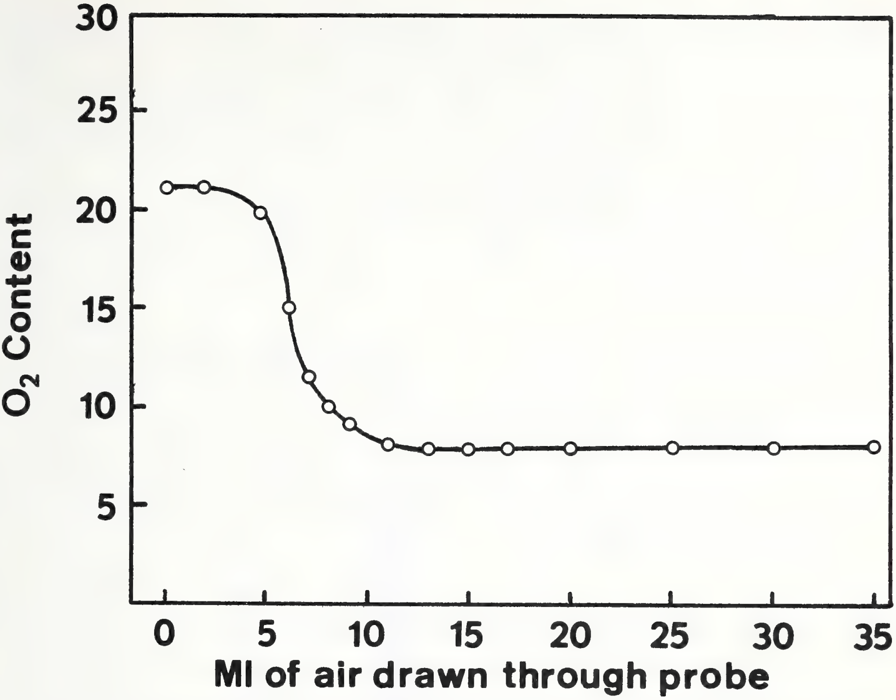

FIGURE 3.—Oxygen content in the analyzer cell as various amounts of soil air were drawn through the probe.

Measuring Oxygen Withdrawn from Air Reservoirs in the Soil

To determine the oxygen content of soil air in both fine-textured and coarse-textured soils a different system was developed in which permanent air reservoirs were established in the soil. These reservoirs were sealed off from the atmosphere and the air in the reservoir allowed to come to equilibrium with the soil air. Samples of air were drawn into a specially constructed analyzer cell for analysis. Reservoirs ¾ inch in diameter and 4 inches long were established at depths of ½, 1, 2, 3, and 4 feet. To establish the air reservoirs an opening ¾ inch in diameter was cut into the soil with a soil sampling tube to a depth 2 inches greater than the desired sampling depth. A No. 4 rubber stopper was slipped on the end of a section of copper tubing of ⅛-inch outside diameter and 1/16-inch inside diameter and the rubber stopper and tubing were forced into the hole far enough so that an opening was left below the stopper. This provided a reservoir with a large soil surface area for exchange of gases between the soil air and the air in the reservoir. The sampling system is illustrated in Figure 4.

Although it fit snugly, the rubber stopper was not an airtight fit in the hole, and an effective seal from contamination by atmospheric oxygen was necessary. This was accomplished by pouring a 3-inch layer of plaster of paris on top of the rubber stopper to stabilize the stopper and tubing. After the plaster had hardened a 2-inch layer of melted paraffin was added to insure a seal. The remainder of the hole was filled with soil and the end of the tubing projecting above the soil surface was made airtight by attaching a small serum cap.

To analyze the air withdrawn from the reservoir for oxygen, a special stainless steel analyzer cell was constructed. A Clark-type oxygen electrode was sealed into the cell. The assembly is shown in Figure 5. The cell was

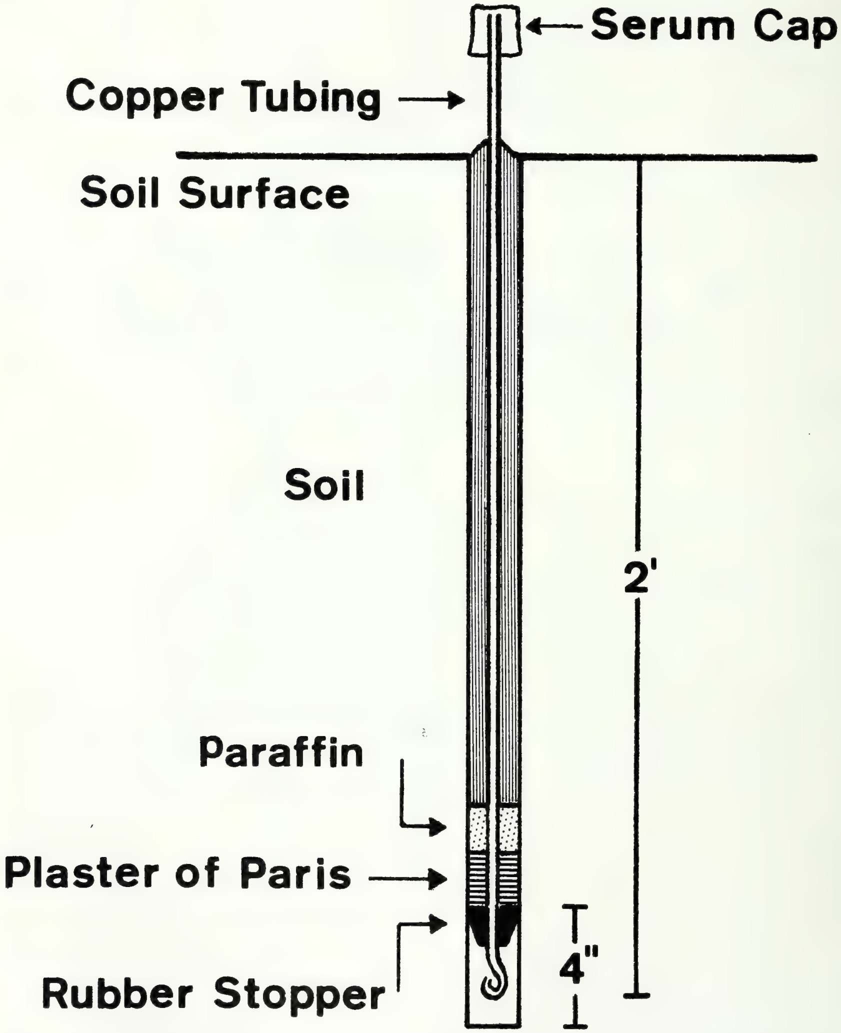

FIGURE 4.—System used for sampling soil air in reservoir. The 2-foot installation is shown here.

designed in such a way that the effective volume of the cell was less than 1 milliliter. The inlet for the oxygen analysis cell was fitted with a hypodermic needle so that the cell could be connected to the air reservoir in the soil profile by simply inserting the needle through the serum cap on the copper tubing leading to the reservoir. The cell could also be easily attached by removing the serum cap and attaching the cell to the tubing with a short piece of rubber tubing. A syringe attached to the cell outlet was used to draw an air sample into the cell. The volume of sample required for analysis by this system was small, 5 milliliters of air drawn through the cell being sufficient for an accurate oxygen measurement (Figure 6).

The air reservoir method of sampling was used for the field analysis of oxygen in this study because of its adaptability over a wider range of soil texture and moisture content than the probe method. The method proved to be very satisfactory for sampling air and analyzing it for oxygen in profiles of soils in the sugar cane area. Installation time of the sam-

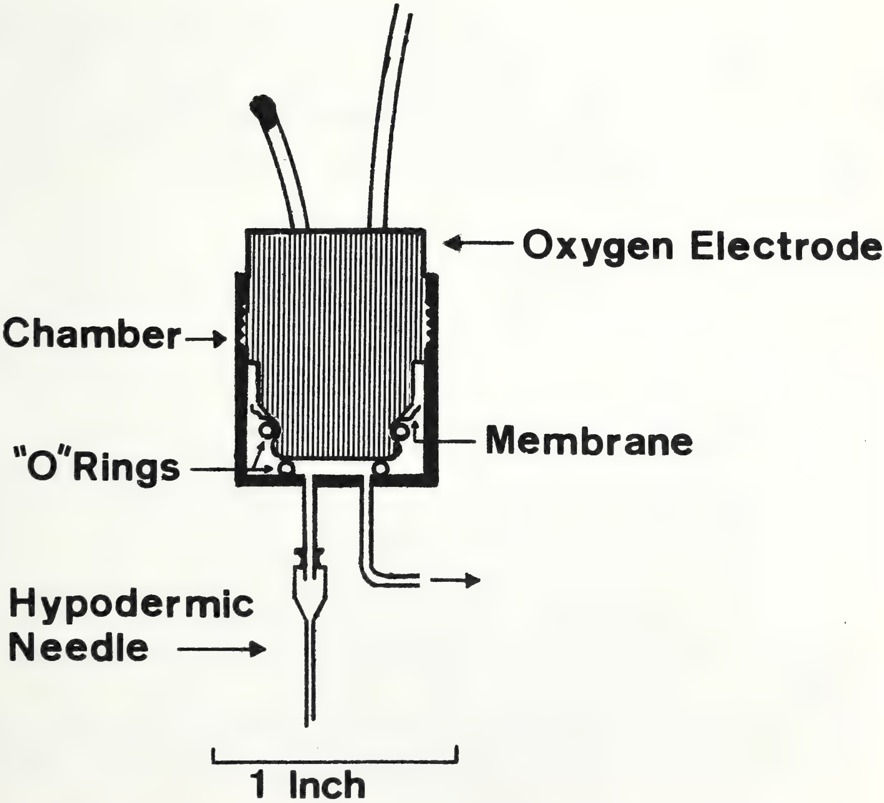

FIGURE 5.—Oxygen analyzer cell used for measuring oxygen content of soil air withdrawn from air reservoir.

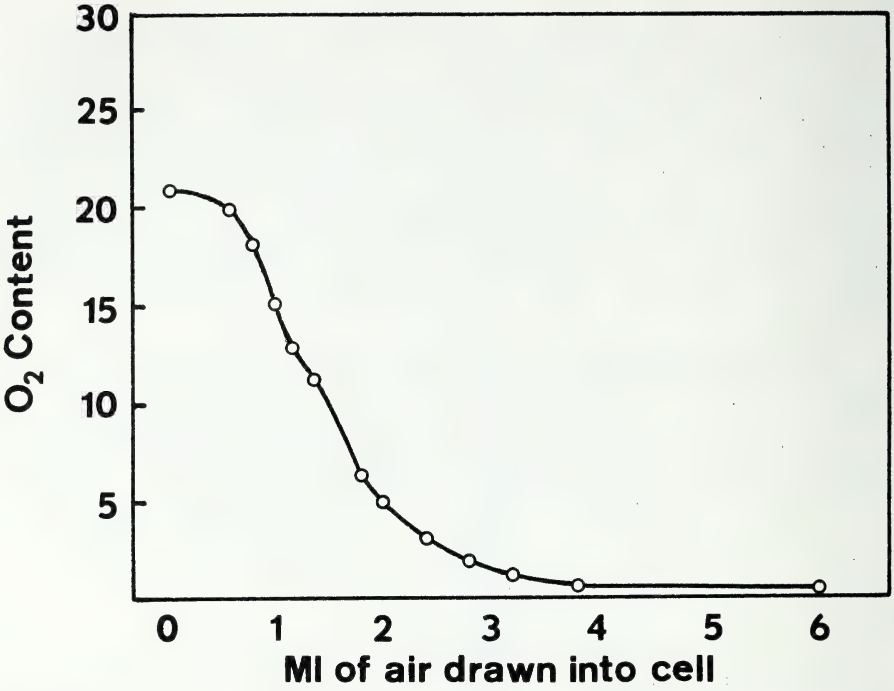

FIGURE 6.—Oxygen content in the analyzer cell as various amounts of soil air were drawn from the air reservoir into the cell.

pling system was reasonably short (about 20 minutes for each installation) and measurements of oxygen at a given depth could be made in about 2 minutes. The agreement between replicate profiles was generally good, considering the inherent variation existing in soils. The reservoirs were established in the 18 soil profiles (three locations of each of six soil series) in early April, 1968, for a total of 90 installations. At a given location the five installations at the different depths were all on the same row and were 3 to 6 feet apart. Oxygen content was first determined on May 2 and at approximately 2-week intervals thereafter except for the last sampling, which was after a 3-week interval.

RESULTS AND DISCUSSION

Oxygen Content of Commerce, Mhoon, and Sharkey Soils (Figures 7 to 9)

If oxygen values of 8 to 10 percent and higher are considered adequate for normal root activity, the oxygen content of the profiles of the three Commerce sites was not critical at any time during the growing season except at the 4-foot depth. At this depth the concentration of oxygen was usually near the 8 percent value. Early in the growing season an oxygen content of 2 percent was recorded at the 4-foot depth at one of the locations. Throughout the season there was a decrease in oxygen concentration with depth. In the early part of the season, differences in oxygen content for a given depth between adjacent replicated sites of the Commerce soil were as large as 5 percent or more. By midseason the oxygen patterns for the three sites were remarkably similar. The fairly close agreement among the three replicate sites of each soil series was also noted for the other five soils. Even though the Commerce soil was the best drained of the three Mississippi River Alluvial soils, the water table in this soil was high enough on several occasions during the first part of the season to flood the oxygen sampling reservoirs at the 4-foot depth and prevent sampling.

Oxygen values in the Mhoon soil showed that aeration throughout

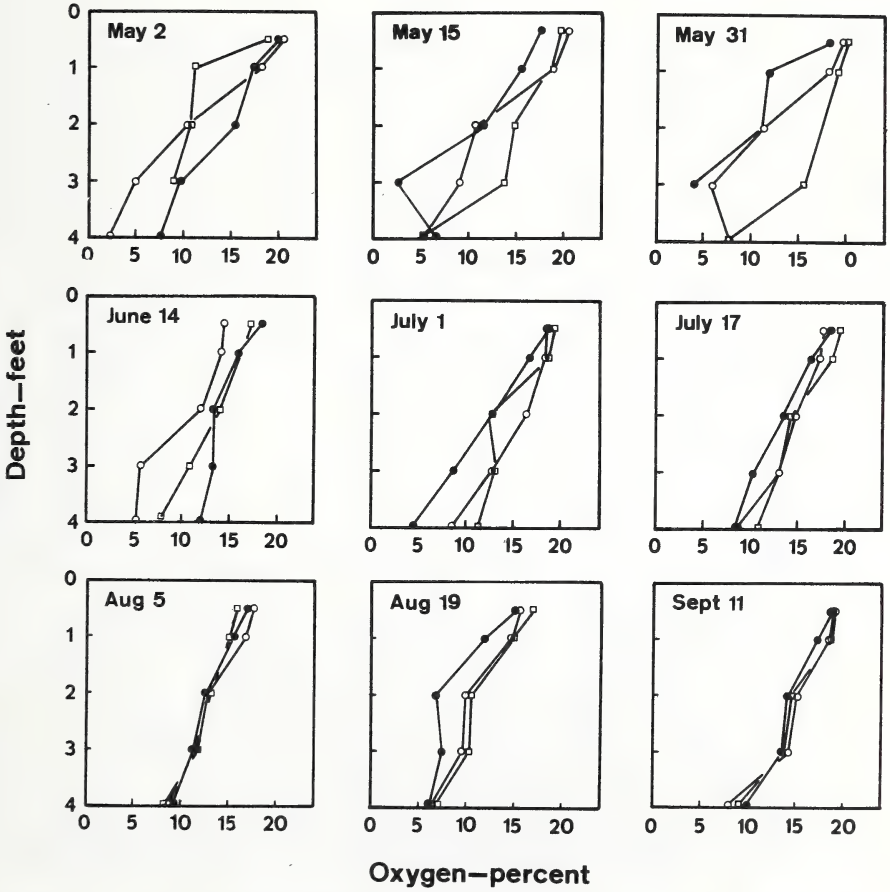

FIGURE 7.—Oxygen distribution in three profiles of Commerce soil in Terrebonne Parish.

the profile was much more critical than in the Commerce soil. A marked decrease in oxygen content with depth was observed, especially during the early part of the growing season. At the 2-foot depth and below, oxygen content throughout the growing season was usually at a point considered too low for adequate root development. A marked lowering of oxygen content occurred at all depths below 6 inches between the August 5 and August 19 samplings. This decrease in oxygen was very likely due to excessive soil moisture resulting from 4.5 inches of rain which fell during this period. A high water content in the surface soil due to a heavy rain can curtail the supply of oxygen to the subsoil because of a blockage of the pore space and is likely to cause a deterioration of roots in the zone where oxygen is depleted, even though the depletion may only persist for a few days.

In the Mhoon soil, as in the other soils, there was a general in-

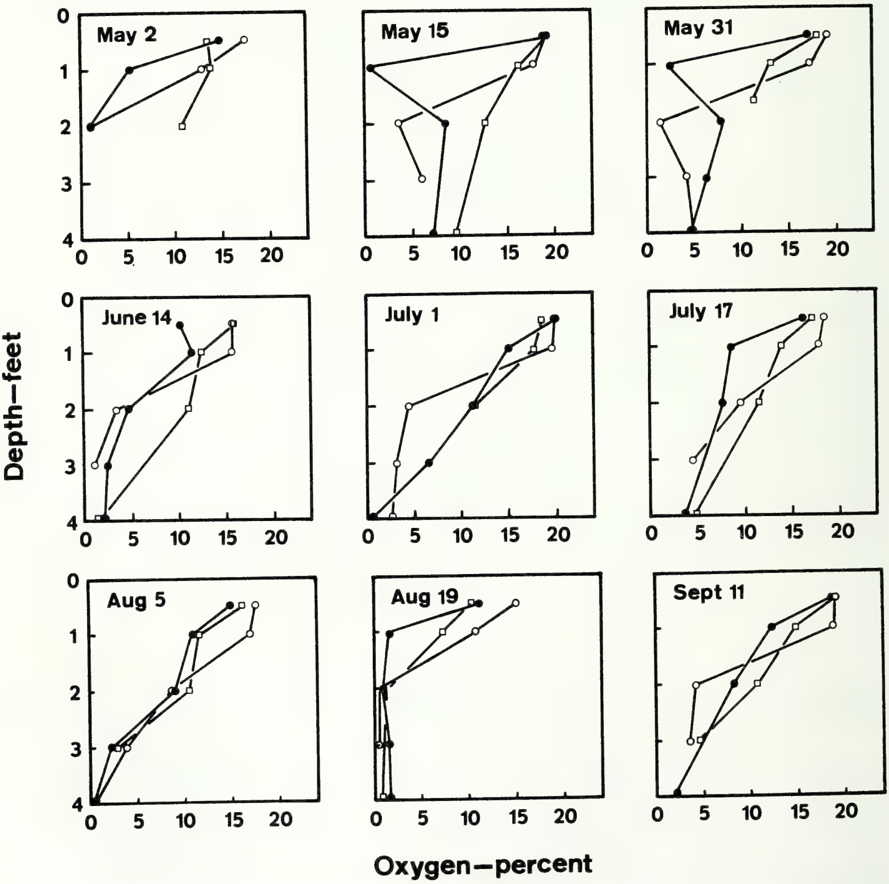

FIGURE 8.—Oxygen distribution in three profiles of Mhoon soil in Terrebonne Parish.

crease in oxygen content in the subsoil as the season progressed. This increase was undoubtedly due to the higher air-filled porosity of the profiles caused by evapotranspiration and downward drainage through the profile. Because of the high water table, difficulty was experienced in obtaining samples at the 3- and 4-foot depths during the first part of the growing season.

Oxygen distribution in the Sharkey soil was similar to that in the Mhoon. Oxygen content below the surface foot was too low to support adequate root activity during the early part of the growing season. As with the other soils, closer agreement in oxygen content among the various sampling sites was obtained during the last part of the season. The Sharkey soil selected for this study was not noticeably different in internal drainage from the Mhoon soil, a fact reflected by the similarity in oxygen patterns. The water table in the Sharkey soil was within 3 feet of the surface throughout most of the season.

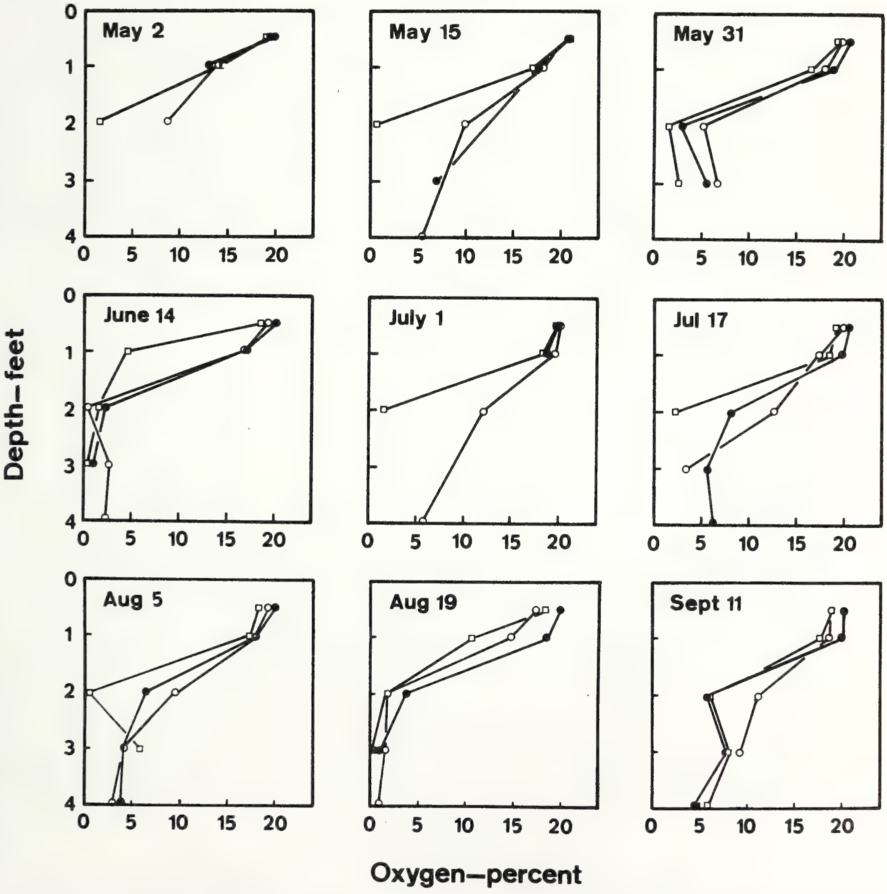

FIGURE 9.—Oxygen distribution in three profiles of Sharkey soil in Terrebonne Parish.

Oxygen Content of Cypremort, Baldwin, and Iberia Soils (Figures 10 to 12)

Oxygen distribution patterns in the Cypremort, Baldwin, and Iberia soils were similar to those in the corresponding Commerce, Mhoon, and Sharkey soils. In the Cypremort soil, which corresponded to the Commerce soil in position and internal drainage, oxygen content was generally adequate for root growth above a 3-foot depth early in the growing season and above 4 feet later in the season. As in all the profiles, aeration generally improved as the season progressed.

In the Baldwin soil, aeration was apparently critical at a depth of 1 foot at the May 15 sampling. All sites had oxygen content below 10 percent at the 2-foot depth and deeper until after the middle of June. Aeration was critical below 3 feet for the entire growing season. The

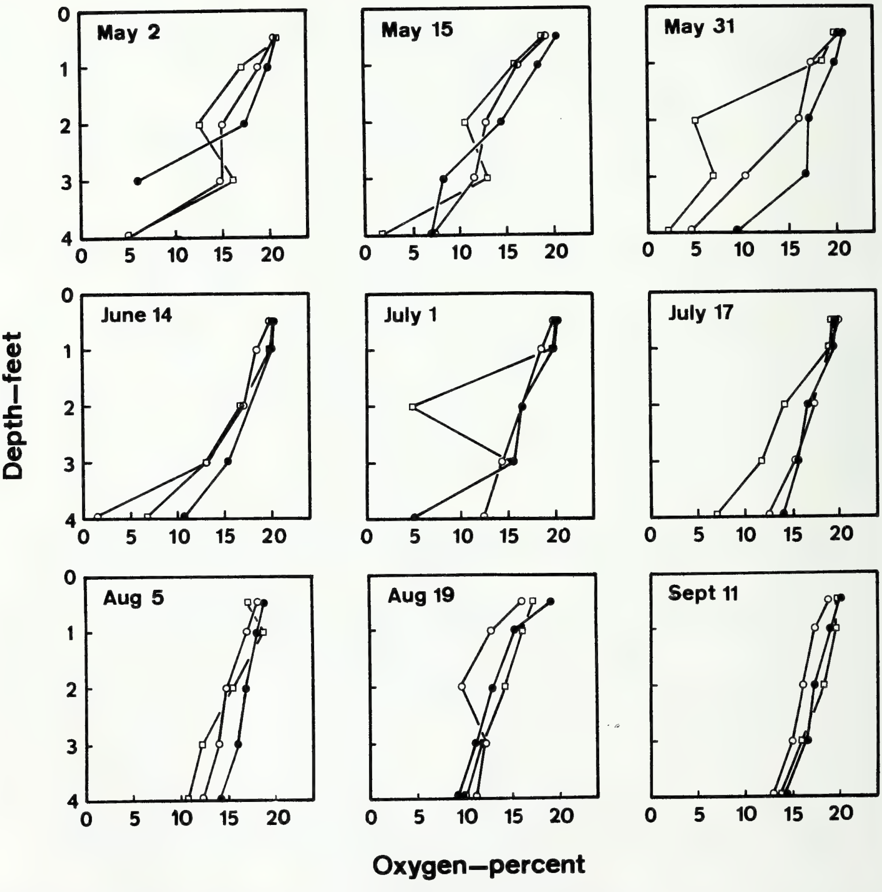

FIGURE 10.—Oxygen distribution in three profiles of Cypremort soil in St. Mary Parish.

water table was lower in the Cypremort, Baldwin, and Iberia soils than in the corresponding Commerce, Mhoon, and Sharkey soils.

The Iberia soil showed oxygen distribution patterns similar to those of the Baldwin soil. Oxygen was critical at depths of 1 foot and deeper early in the growing season, with the zone of apparently adequate oxygen content gradually deepening as the season progressed.

In order to obtain information on the amount of air space available for gas exchange in the soils, each profile was sampled near the end of the growing season (on September 24) to determine the relative volumes of air, water, and soil solids. The results of these analyses are shown in Figure 13. Except in the surface foot or so, air space was low in most of the soils. The Sharkey and Iberia soils, and to a lesser degree the Mhoon soil, were especially low in air space at the lower depths. These low air space values are in line with the low oxygen content below 2 feet in these soils.

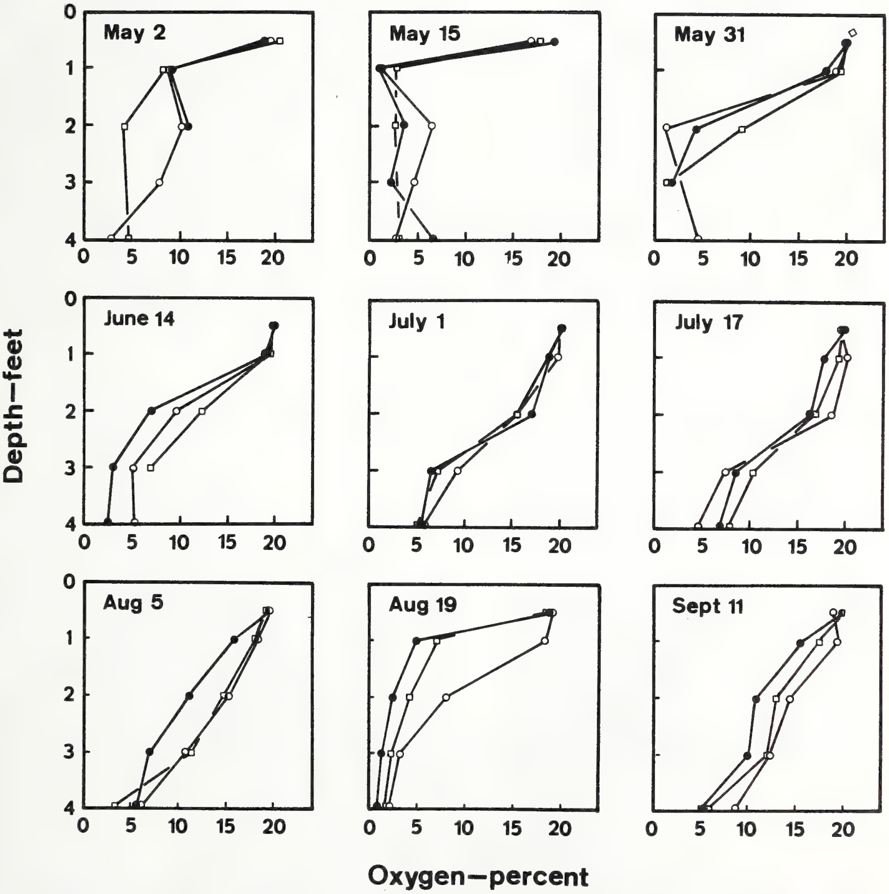

FIGURE 11.—Oxygen distribution in three profiles of Baldwin soil in St. Mary Parish.

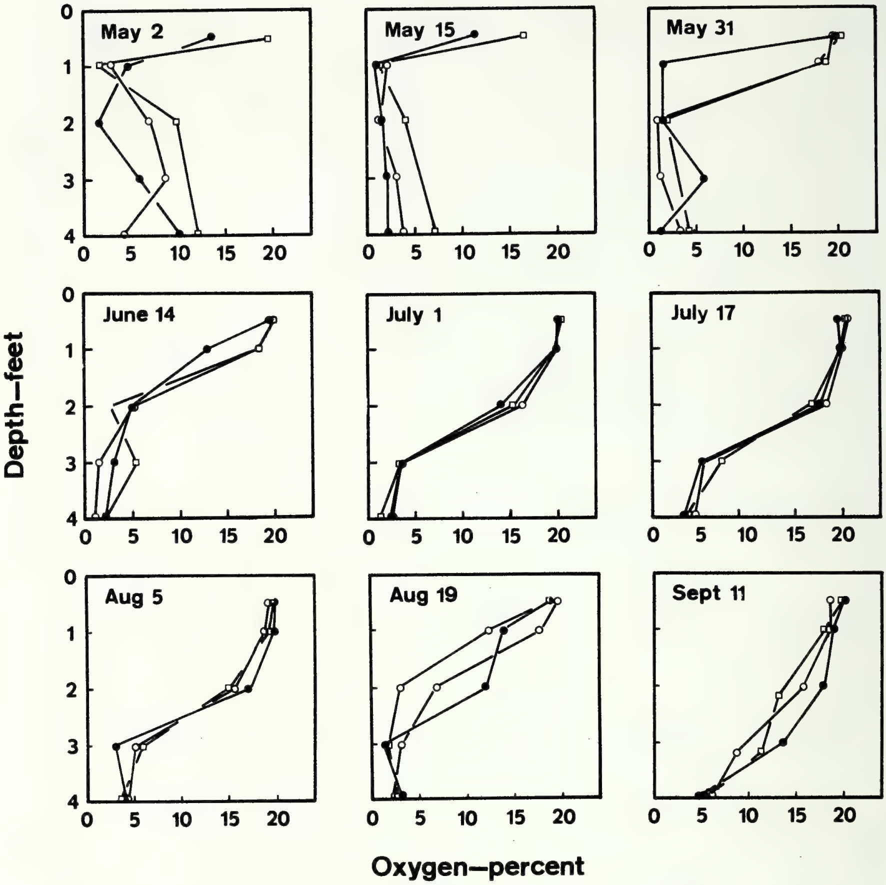

FIGURE 12.—Oxygen distribution in three profiles of Iberia soil in St. Mary Parish.

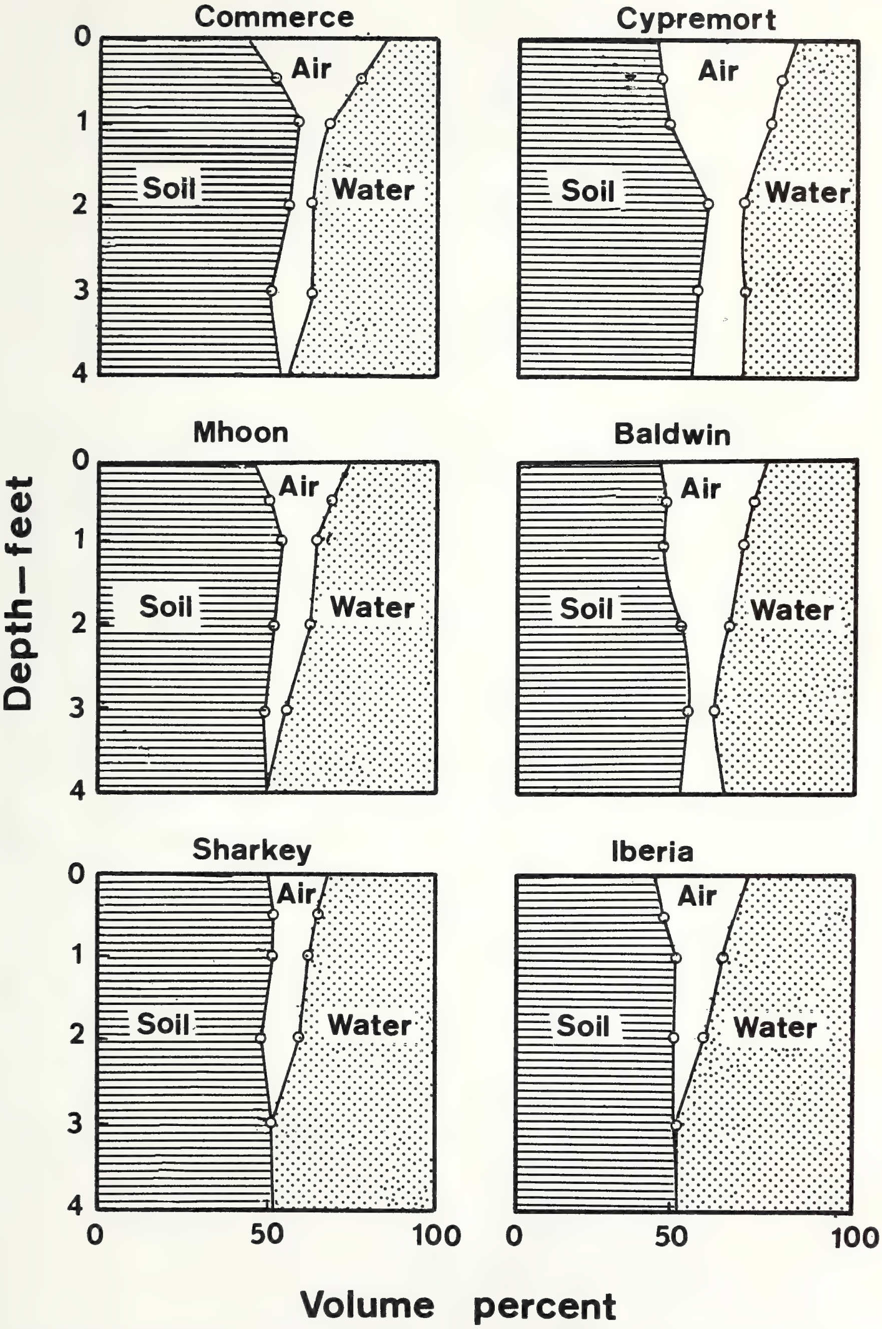

FIGURE 13.—Volume distribution of soil solids, air space, and water for the six soils used in this study. Each profile represents an average of three locations.

Root Distribution

Excavations were made at each of the 18 sampling sites on September 24 to determine the distribution of sugar cane roots in the soil. Cylindrical volumes of soil approximately 8 inches in diameter and either 6 inches or 1 foot in length, corresponding to the oxygen sampling depth, were removed from each site. The roots were separated from the soil by washing and were dried and weighed.

The distribution of roots at various depths in the soil is shown in Figure 14 for the Commerce, Mhoon, and Sharkey soils and in Figure 15 for the Cypremort, Baldwin, and Iberia soils. There were differences in root distribution among the soils but these were not as striking as the differences in oxygen content. All of the soil profiles showed only a small amount of roots at the lower depths irrespective of oxygen content at these depths.

With the exception of the Sharkey soil, in which recovery of roots in the surface layer was poor because of the difficulty of separating clay from the roots, all of the soils had about the same root concentration in the surface 6 inches. In the critical 6-inch-to-2-foot depth, however, there

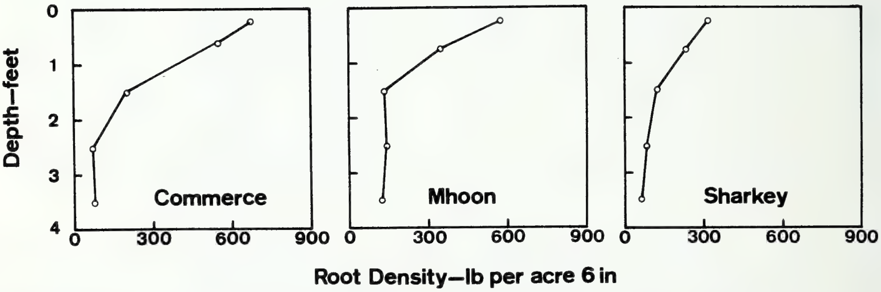

FIGURE 14.—Root distribution of Commerce, Mhoon, and Sharkey soils. Each profile represents an average of three locations.

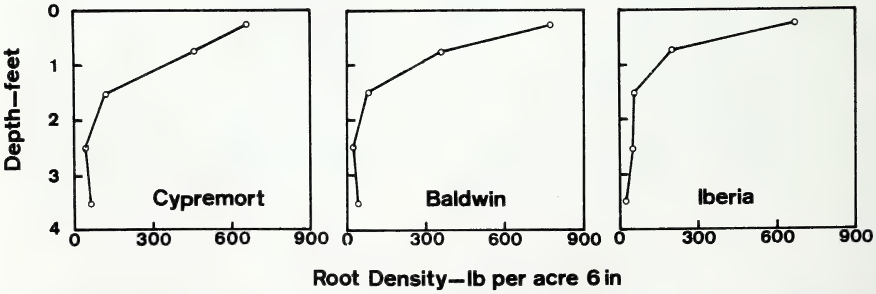

FIGURE 15.—Root distribution of Cypremort, Baldwin, and Iberia soils. Each profile represents an average of three locations.

were marked differences in root content that were related to oxygen content. Figure 16 shows the relationship between the average oxygen content at the 2-foot depth for the period May 2 through July 1 and the root concentration in the 6-inch-to-2-foot zone. The controlling effect of oxygen content at 2 feet during this period on the development of sugar cane roots is striking, with a threefold increase in root content associated with a threefold increase in average oxygen content. Root concentration in the 6-inch-to-2-foot zone was much higher in Commerce and Cypremort soils than in the corresponding Sharkey and Iberia soils, with the Mhoon and Baldwin soils being intermediate.

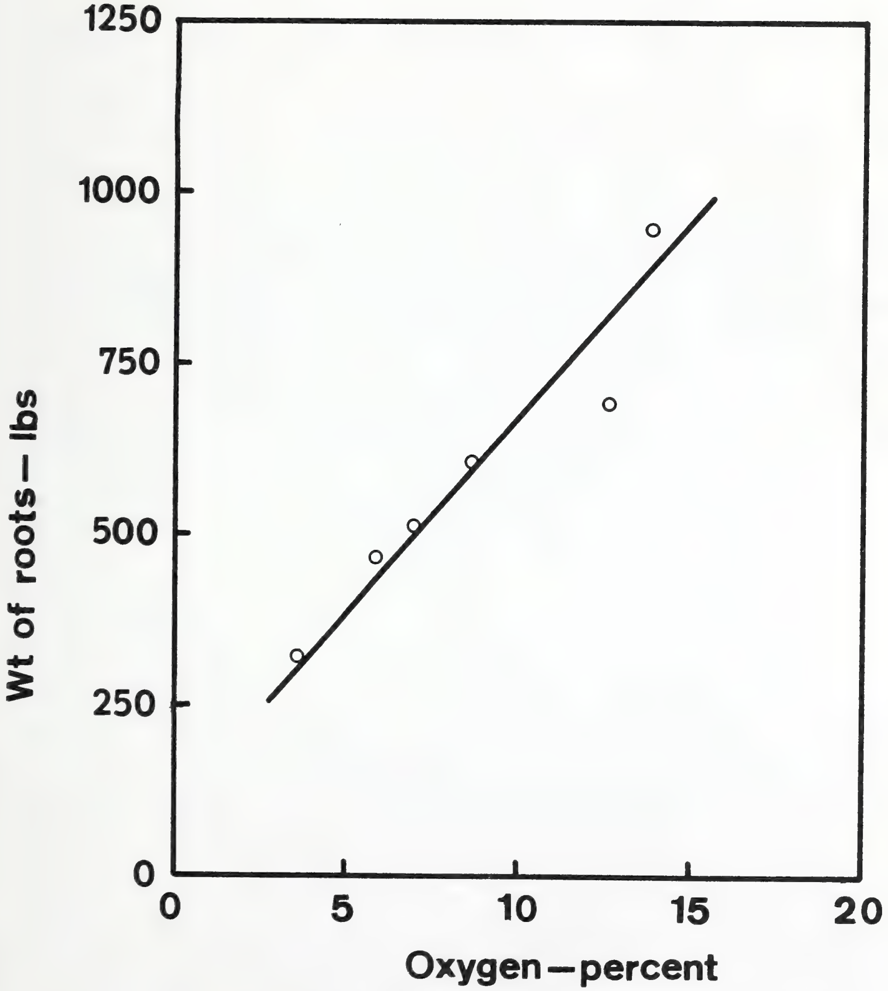

FIGURE 16.—Relationship between average oxygen content at the 2-foot depth for the period May 2 through July 1 and the amount of roots (oven-dry) in the 6-inch-to-2-foot depth on Sept. 24.

Oxygen measurements at the 2-foot depth probably gave a better characterization of the aeration status of the root zone than oxygen measurements at any other depth. Adequate oxygen content at 2 feet usually insured that aeration was not limited in the critical root zone above this depth. The relationship obtained here between oxygen content and root distribution also emphasizes the importance of maintaining adequate aeration in the soil during the first part of the growing season. In some of the poorly aerated profiles the oxygen content at the 2-foot depth improved after July 1 but there was no corresponding increase in root development. As was pointed out above, all soils had only a small amount of roots at the lower depths regardless of the aeration status.

SUMMARY

Two methods were developed for sampling soil air and analyzing it for oxygen content in the sugar cane area. One method consisted of inserting a metal probe into the soil and using a vacuum to draw an air sample into a polarographic cell for oxygen analysis. The second method employed permanent air reservoirs at different depths in the soil from which air was withdrawn for analysis in a similar polarographic cell. The second method was employed in this study because of the difficulty of withdrawing samples of air from fine-textured or wet soils with the probe method.

Oxygen analysis of the soil air throughout the growing season for two groups of three soils that differed in elevation and internal drainage showed much higher oxygen content at depths below 6 inches in the Commerce and Cypremort soils than in the other four soils. In the Mhoon, Sharkey, Baldwin, and Iberia soils, oxygen content in the subsoil was often at levels considered inadequate for optimum root activity, especially in the first part of the growing season.

Except for the Sharkey soil, in which difficulty was experienced in separating the clay from the roots, root distribution was generally about the same for all soils in the surface 6 inches, which probably reflected the adequate aeration that existed at this depth, and at the 3- and 4-foot depths, where little root development occurred. There were marked differences among the soils in root content in the 6-inch-to-2-foot zone, however, with the better aerated soils showing a much higher root development. A close relationship was measured between oxygen content at the 2-foot depth during the first half of the growing season and the amount of root development in the 6-inch-to-2-foot zone.

The results of this study emphasize the importance of good aeration in the surface 2 feet of soil during the first part of the growing season for adequate root development of sugar cane. Adequate aeration at lower depths is probably important, but apparently to a lesser degree.

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Silage and Wheat Pasture for Wintering and Finishing Weanling Calves

JOHN C. CARPENTER, JR. AND R. H. KLETT

BULLETIN NO. 642 DECEMBER 1969

LOUISIANA STATE UNIVERSITY
AND AGRICULTURAL AND MECHANICAL COLLEGE
AGRICULTURAL EXPERIMENT STATION
DOYLE CHAMBERS, DIRECTOR

Silage and Wheat Pasture for Wintering and Finishing Weanling Calves

JOHN C. CARPENTER, JR., AND R. HOLLIS KLETT*

Louisiana beef cattle producers are becoming more aware of the need for retaining ownership of their calves for an additional growing period following weaning. Economic returns from the average weaned calf are insufficient to defray cow costs during the year. The ultimate program appears to be one that provides a cheap source of feed during a period between weaning and 600 to 750 pounds, followed by a drylot period for finishing to the desired market weight and grade.

Economic data (Heagler *et al.,* 1967) from six feedlots in the Mississippi Delta area have shown that cattle can be fed economically on rations consisting of high-energy corn silage. Gains were made at a cost of 14.5 cents per pound during a period of growth from feeder calf (592 pounds) to slaughter steer (908 pounds). Daily gains were 1.98 pounds on 28 pounds of silage per pound of gain.

Michigan workers (Henderson and Greathouse, 1968) reported studies involving the supplementation of silage with concentrates to regulate gains. Cattle gained faster and graded higher in the Choice grade at the higher levels of grain feeding. Feed costs increased and pounds of choice beef produced per acre of corn fed decreased with increasing levels of grain feeding.

The use of winter pastures for growing and developing weanling calves to feedlot weights is expanding rapidly in Louisiana. Huffman *et al.* (1967) reported production performance, costs, and returns for winter-grazing spring calves on wheat-ryegrass pastures in central Louisiana. Cattle winter-grazed for 150 days gained 1.25 pounds per day at a cost of 15 cents per pound of gain. Net returns per calf were approximately $25. Carpenter *et al.* (1969) reported daily gains of 1.75 pounds on ryegrass pasture during a 140-day grazing period prior to finishing in drylot.

Recent development of high-yielding sorghum hybrids has been responsible for renewed interest in using sorghum forage for silage. However, results in a recent study in Oklahoma (1968) showed corn silage to be generally more desirable for feeding steers than forage sorghum silage. Daily consumption of the sorghum silage was 12 per cent less than daily consumption of corn silage. Reported gains were 1.84 and 1.15 pounds for corn silage and sorghum silage, respectively. Baird *et al.*

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*Northeast Louisiana Experiment Station, St. Joseph, La., and formerly, Department of Animal Science, LSU, Baton Rouge, La., respectively. The study reported was conducted at the Northeast Louisiana Experiment Station.

(1958) reported that corn and sorghum silages were more economical to feed than hays; however, there appeared to be a definite need for concentrate feed in addition to silage to meet the energy requirements for fattening.

Findings from the previous reports suggest that forage silages in combination with grain supplementation can be used economically for growing and fattening beef steers. Animal performance can be regulated with the use of concentrates.

The following study was developed to determine the feasibility of using several wintering rations consisting of silage and wheat pasture as growing rations during the period between weaning and finishing in the drylot. A comparison of sorghum silage with and without concentrates, corn silage, and wheat pasture was completed during a three-year period from 1966 through 1968.

PROCEDURE

Preparation of Forage Crops

Land for wheat pasture was prepared in September following the harvesting of silage. The land was disked two or three times prior to planting. Wheat and fertilizer were applied on the surface and then 40-inch rows were formed with a middlebuster. The seeding rate was 2.5 bushels per acre, with 67 pounds of nitrogen (ammonium nitrate) applied per acre. Wheat pasture was available for grazing during a 144-day period.

Land for corn silage was prepared by disking twice and using a middlebuster to build 40-inch rows. Nitrogen (ammonium nitrate) was applied in the middle of the rows at the rate of 120 pounds per acre. Corn was planted and broadcast-sprayed with 2 pounds of 80 per cent Atrozine per acre. The corn was cut at the well-dented (flint) stage in one-half inch lengths and stored in trench silos. Black plastic was used as a cover to prevent spoilage.

Seedbeds for sorghum silage were prepared in the same way as those for corn, with ammonium nitrate applied at the same rate. Sorghum usually was planted during the latter part of April or the first part of May. Following planting, the area was broadcast-sprayed with 2.2 pounds of Propazine per acre. Two cuttings were obtained from the sorghum each year. Sorghum silage was stored in the same manner as corn silage.

Handling of Cattle

Each fall, 36 weanling beef steer calves averaging approximately 450 pounds and grading Good were purchased for the study. The animals were randomly divided into four equal groups and assigned to the following treatments:

Lot 1—Sorghum silage and cottonseed meal.
Lot 2—Corn silage and cottonseed meal.
Lot 3—Wheat pasture grazing.
Lot 4—Sorghum silage and cottonseed meal with ground shelled corn.

Following a 174-day wintering period, the steers were combined into one group and self-fed the concentrate ration shown in Table 1. The cattle were fed for 98 days and slaughtered.

TABLE 1.—Concentrate Ration[1]

Ingredients	Pounds/ton
Yellow corn meal	1,340
Cottonseed meal (41%)	200
Urea (45% N)	20
Cottonseed hulls	300
Molasses	100
Salt	20
Calcium carbonate	20

[1] Vitamin A added at the rate of 15,000 IU/10 lb. ration.

During the wintering period, salt and a mineral mixture consisting of two parts dicalcium phosphate and one part salt were fed free-choice. Lice and flies were controlled with a pour-on systemic and backrubbers, respectively. The steers were individually number-branded and implanted with 24 mg. of diethylstilbestrol at the beginning of each trial. A second implant of 24 mg. of diethylstilbestrol was given approximately 150 days later.

RESULTS AND DISCUSSION

Results of the wintering phase of the study are presented in Table 2. In all trials, the poorest performance as measured by total gain or average daily gain was observed for cattle fed sorghum silage and cottonseed meal. However, when concentrates were added to increase the energy content of the sorghum silage, performance increased to equal that of cattle fed corn silage and cottonseed meal. These data support previous work by Baird *et al.* (1958) which indicated that sorghum silage, when used as either a growing or finishing ration, was generally too low in energy to promote performance comparable to that obtained with corn silage.

Wheat pasture grazing resulted in the highest average daily gain; however, this period was shorter by 30 days, which may have affected

TABLE 2.—Results of Silage Feeding and Wheat Grazing, Three-Year Average (October-April; 174 Days) 1966-68

Treatment	Sorghum silage + CSM	Corn silage + CSM	Wheat grazing	Sorghum silage + CSM + corn
Lot No.	1	2	3*	4**
Number of animals/year	9	9	9	9
Final wt., lb.[1]	620^a	713^b	706^b	689^b
Initial wt., lb.	447	446	447	445
Total gain per steer, lb.	173^a	267^b	259^b	244^b
Daily gain, lb.	$.99^a$	1.53^b	1.80	1.44^b
Total feed per steer, lb.				
Sorghum silage, lb.	7,078			7,567
Corn silage, lb.		7,669		
C. S. meal, lb.[2]	334	334		323
Corn meal, lb.				485
Daily feed per steer, lb.				
Sorghum silage, lb.	40.68			44.78
Corn silage, lb.		44.07		
C. S. meal, lb.	1.92	1.92		1.91
Corn meal, lb.				2.87

* Wheat grazing only 144 days.

**Two years' results, 1967 and 1968, for an average of 169 days.

[1] All values, where applicable, are averages.

[2] Vitamin A added.

[ab] Means on the same horizontal line with different superscripts are significantly ($P < .05$) different.

the performance. Had the cattle been allowed to stay on pasture for the same period of time as those on silage, the rate of daily gain might have decreased. Neverthless, these cattle gained comparably and in excess of those on the other treatments, indicating that wheat pasture, when grazed, provides adequate nutrients for fattening.

It is of interest to note that sorghum silage supplemented with approximately 3 pounds of corn per head daily is roughly equivalent to corn silage. This was important since the tonnage of sorghum silage produced per acre was almost twice that of corn silage. These data suggest that it may be more feasible to produce sorghum silage, since yields are higher than those of corn, and to supplement it with concentrates to raise the total energy intake of the animal. Corn or milo grain can be added as needed to raise the energy intake.

Total feed consumed per steer was greatest for the lot fed sorghum silage plus cottonseed meal and ground corn, followed by the lot fed corn silage and cottonseed meal, and was significantly lower for the lot fed sorghum silage and cottonseed meal. The lot fed sorghum silage and cottonseed meal consumed the least amount of silage and also had the lowest rate of gain, which supports earlier statements concerning energy intake. Cattle in this lot apparently were limited in feed intake by bulk, since the sorghum silage was higher in fiber (28 per cent) than the corn silage (24 per cent). There was also less energy consumed by the lot fed sorghum silage since consumption was significantly lower than in the other treatments. Cattle fed sorghum silage plus cottonseed meal and corn consumed more silage than those on sorghum silage alone.

These data indicate that added concentrates stimulated consumption of silage either by increasing the palatability of the ration or by increasing dry matter digestion in the rumen, which resulted in decreased retention time of the silage in the rumen-reticulum area. This is supported by the fact that a number of workers have shown forage intake to be more closley related to rate of digestion than over-all digestibility (Donefer *et al.*, 1960; Johnson *et al.*, 1962; Balwani *et al.*, 1969). It may also be possible that cattle tire of sorghum silage when it is fed as the single feedstuff.

Feedlot and carcass data for the steers are presented in Table 3. Ani-

TABLE 3.—Results of Fattening Following Wintering on Silage or Wheat Grazing, Three-Year Average (April-July; 98 Days) 1966-68*

Previous treatment	Sorghum silage + CSM	Corn silage + CSM	Wheat grazing	Sorghum silage + CSM + corn
Lot No.	1	2	3	4
Final wt., lb.[1]	844[a]	921[b]	931[b]	911[b]
Initial wt., lb.	620[a]	713[b]	706[b]	689[b]
Total gain per steer, lb.	224	208	225	222
Daily gain, lb.	2.29	2.12	2.30	2.27
Concentrate int./hd./day, lb.	20.93	20.93	20.93	20.93
Concentrate int./lb. gain, lb.	9.14[a]	9.87[b]	9.10[a]	9.22[a]
Carcass data[2]				
Weight, lb.	493	545	552	531
Grade	10.34	9.99	10.56	10.07
Dressing per cent[3]	59.70	60.08	60.98	59.79
Fat thickness, inches	.29	.30	.28	.30
Yield grade	2.93	2.95	2.93	2.95
Ribeye muscle area, sq. in.	9.65	10.42	10.47	10.08

*Drylot feeding period for 1967 and 1968 averaged 95 days.

[1] All values, where applicable, are averages.

[2] Carcass grades based on 9 as Low Good, 10 as Average Good, and 11 as High Good. Carcass data is an average for 1967 and 1968.

[3] Dressing per cent is warm carcass weight less 2% divided by weight prior to slaughter.

[ab] Means on the same horizontal line with different superscripts are significantly ($P < .05$) different.

mal performance in drylot was not significantly affected by the previous treatments. There was a tendency for the group fed corn silage to be slightly less efficient in concentrate conversion, which was probably due to their heavier weight when starting in the drylot feeding program. Differences in carcass traits for all treatments were not significant. These data indicate that feeding regimes during the wintering period have little if any effect on carcass traits, with the exception of final carcass weight. This appears to result from the wintering phase, since the cattle fed sorghum and cottonseed meal gained less during this period and were significantly lighter in weight at the beginning of the drylot period. All of the cattle gained approximately the same amount during the last period, indicating that the group fed sorghum and cottonseed meal did not compensate for their low performance during the wintering period. These data are contradictory to those reported by Peacock *et al.* (1964). They reported that daily gains during a 140-day feedlot period were inversely related to winter gains.

Combined gains for each treatment during 272 days of the trial are presented in Table 4. Gains by the group fed sorghum silage and cottonseed meal were significantly lower than those in the other groups. Based on these data, sorghum silage when fed without added energy will not support adequate performance.

TABLE 4.—Results of Combined Wintering and Drylot, Three-Year Average (October-July; 272 Days) 1966-68

Lot No.	1	2	3	4
Total gain per steer, lb.	397^{a}	474^{b}	483^{b}	466^{a}
Daily gain, lb.	1.46^{a}	1.74^{b}	1.78^{b}	1.71^{b}

^{ab}Means on the same horizontal line with different superscripts are significantly ($P<.05$) different.

SUMMARY AND CONCLUSIONS

The study was designed to compare winter rations consisting of wheat pasture, corn silage, and sorghum silage with and without added concentrates. Steers weighing approximately 450 pounds were fed and/or winter-grazed for 174 days during a three-year period from 1966 through 1968. Following the wintering period, all steers were self-fed an 85 per cent concentrate mixture for 98 days and slaughtered.

Cattle fed sorghum silage alone exhibited the poorest performance. When concentrates were added to sorghum silage at the rate of 3 pounds per head daily, performance increased to equal that of the corn silage group. The grazing cattle had the highest daily gain; however, wheat pasture was available for only 144 days. These cattle were fed corn silage during the first 30 days.

Feed consumed per steer was significantly lower for the group fed sorghum silage, was intermediate for the group fed corn silage, and was highest for the group fed sorghum silage plus ground corn. It was concluded that added concentrates stimulated consumption of the silage either by increasing the palatability of the ration or by increasing dry matter digestion in the rumen and thereby decreasing retention time in the rumen-reticulum area.

Feedlot and carcass traits were not significantly influenced by the wintering treatment. Combined gains during the 272-day trial indicated that sorghum silage alone lacked sufficient energy to support performance comparable to the other treatments. Compensatory gain during the drylot period was not evident as anticipated, which resulted in significantly lower final live and carcass weights.

The selection of one of these programs depends on the performance desired, the amount of land present, and the yield of silage per acre. It should be kept in mind that sorghum silage will produce almost twice the tonnage per acre as corn silage. These data suggest that it may be more feasible to produce sorghum silage and supplement it with concentrates to raise the total energy intake of the animal.

(See back cover page for rib pictures from the four treatments.)

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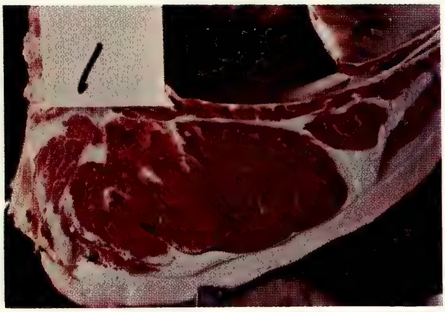
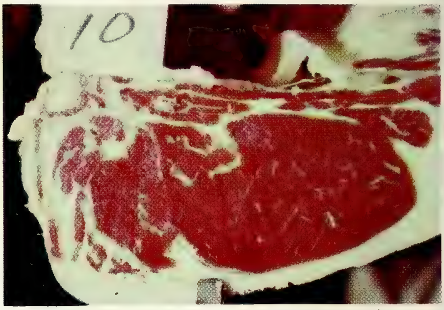
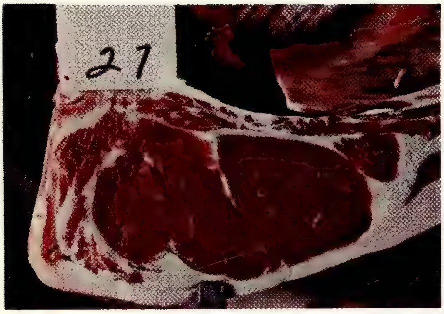
12th Rib from the Four Treatments



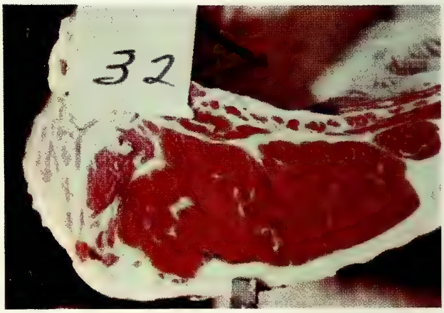
LOT 1—
Sorghum silage and cottonseed meal



LOT 2—
Corn silage and cottonseed meal



LOT 3—
Wheat pasture grazing



LOT 4—
Sorghum silage and cottonseed meal with corn

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Producing Slaughter Steers With Temporary Grazing Crops And Concentrates

OHN C. CARPENTER, JR., R. H. KLETT AND SHERMAN PHILLIPS

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Producing Slaughter Steers With Temporary Grazing Crops and Concentrates

John C. Carpenter, Jr., R. Hollis Klett
and Sherman Phillips*

Interest among livestock producers in Louisiana in holding beef calves beyond weaning has increased in recent years. The cow-calf producer can no longer afford to sell lightweight calves at weaning since the cow-cost for a year has risen beyond the receipts obtained from sale of the calf.

Duncan and Felts (1961) produced slaughter cattle weighing 1,000 pounds by grazing pastures through the winter and summer with a short drylot finishing period of 70 days at the end of the study. Wise *et al.* (1965) and Carpenter *et al.* (1968) finished weanling steers on pasture with concentrates fed at the rate of 1 per cent of body weight.

Edwards *et al.* (1968) compared pasture and drylot programs for producing slaughter steers weighing approximately 1,000 pounds. They reported poorer animal performance from pasture; however, when considering net returns, these cattle were more profitable. McClaugherty and Carter (1961) reported excellent performance when steers were grazed and fed approximately 20 to 25 bushels of corn as a supplement to pasture during the last 160 days of the grazing season. They further showed that yearling steers fed 20 to 25 bushels of corn on pasture prior to finishing in drylot could be expected to reach the Choice grade about 60 days sooner than similar steers grazing pasture alone.

The desirability of harvesting green chop and feeding it daily has attracted the interest of some Louisiana producers. This method has been used in the dairy industry, but has received little consideration in beef production programs. Wise *et al.* (1965) compared green chop *vs.* grazing, feeding supplemental concentrates at approximately 1 per cent of the animal's body weight. Grazing steers gained 0.2 of a pound more per day while consuming 30 per cent less concentrates than steers fed green chop. No large differences were observed in carcass traits. It was concluded that green-chopping forage had limited application in the Southeastern United States.

The nutritive value of green chop appears to be similar and in some instances higher than when the same forages are preserved as silage. Balwani *et al.* (1969) reported higher dry matter, protein, and cellulose digestion for green chop forage when compared with silage and hays. The green chop contained less dry matter, organic matter, and cellulose, but was significantly higher in crude protein content than the silage.

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Research reported in this bulletin was designed to study various methods using a maximum of temporary grazing crops and a minimum of concentrates for producing slaughter steers weighing 900 to 1,000 pounds. The research was conducted at the Macon Ridge Branch Experiment Station, Winnsboro, Louisiana, from 1966 through 1968.

The over-all study was divided into the following phases:

Phase 1—Grazing ryegrass pastures.

Phase 2—Finishing in drylot and on pasture.

Phase 3—Drylot fattening following grazing or green chop.

PHASE I

Grazing Ryegrass Pastures

Procedure

Each year pasture plots were disked twice in September, with 6-24-24 and ammonium nitrate applied at a rate of 200 pounds of each per acre. Ryegrass was seeded at the rate of 40 pounds per acre. Ammonium nitrate was applied in February at the rate of 100 pounds per acre. In 1967, all pastures received a second application of 100 pounds of ammonium nitrate per acre in March.

During January of each year 106 beef steers grading Good and weighing approximately 450 pounds each were purchased for grazing ryegrass pastures. The calves were allowed to graze until the last of May. The steers were wormed, number-branded, and implanted with 12 mg. of diethylstilbestrol at the beginning of each trial. A second implant of 24 mg. of diethylstilbestrol was administered to each animal in May before the start of Phase 3. Salt and a mixture of two parts bone meal and one part trace mineralized salt were fed free-choice. A pour-on systemic insecticide and back-rubbers were used to control lice and flies, respectively.

Results and Discussion

The ryegrass pastures were stocked at the rate of 1.5 steers per acre. There appeared to be an abundance of forage during each grazing period. The average gain per steer during the 134 days was 234 pounds, for an average daily gain of 1.75 pounds. This resulted in the production of 351 pounds of beef per acre. These data are similar to those obtained by Carpenter *et al.* (1966) and Castellanos and Klett (1969), which showed steers to gain approximately 1.70 pounds per day over a 140-day grazing period on ryegrass pastures.

PHASE 2
Finishing in Drylot and on Pasture

Cattle winter-grazed in Louisiana are generally shipped to out-of-state feedlots for finishing. Interest among Louisiana producers in finishing their own cattle to slaughter weights and grades led to the second phase of the over-all study. This phase was further divided into two studies. Study No. 1 was designed to measure the effect of fans vs. no fans, under artificial shade, on the performance of steers fed in drylot during summer periods. Study No. 2 was planned to compare the results of grazing and of feeding green chop, both with and without concentrates. Concentrates were fed at the rate of one pound per 100 pounds of body weight (1 per cent).

The following treatments were imposed:

Study No. 1

Lot 1—Drylot, fans and shade, full-fed 104 days (17 steers/yr.).
Lot 2—Drylot, shade, full-fed 104 days (17 steers/yr.).

Study No. 2

Lot 1—Grazing 81 days (18 steers/yr.).
Lot 2—Green chop 81 days (18 steers/yr.).
Lot 3—Grazing and concentrates (1%), 81 days (18 steers/yr.).
Lot 4—Green chop and concentrates (1%), 81 days (18 steers/yr.).

The rations used as the concentrate feed with grazing and green chop, and in the drylot, are shown in Table 1.

TABLE 1.—Experimental Rations

Ration	Concentrate[1] lb.	Drylot[2] lb.
Ground yellow corn	1,940	1,340
Cottonseed hulls		300
Cottonseed meal		200
Urea	30	20
Calcium carbonate	10	20
Salt	20	20
Molasses		100
	2,000	2,000

[1] Concentrate ration fed at 1% of the animal's body weight during Phase 2 of the study.
[2] Ration fed to cattle in drylot during Phase 3.

STUDY NO. 1 (PHASE 2)

Previous research has indicated that properly designed structures to provide shade will reduce the radiation heat load on an animal by 50 per cent or more. However, Rozen *et al.* (1961) indicated that although providing shade for protection against solar radiation has contributed significantly to the performance of beef cattle in the hot, dry Southwestern United States, there has been no significant advantage attributed to shade in the more humid, lower solar radiation conditions of the Southeastern United States.

It has also been demonstrated that an increase in air movement aids in removing excess heat from the body, thereby reducing the body temperature of the animal. Kibler and Brody (1954) have shown that, at air temperatures between 75° and 95° F., increasing air movement from 0.5 to 5 meters per hour reduced the heat stress of the animal. Similar results were noted by Ittner *et al.* (1958).

Cattle in this study were taken from winter pasture (ryegrass--Phase 1) and placed directly in the feedlot and fed for 104 days during the summer. The objectives were to compare the effect of shade, with and without fans, on the performance of steers in drylot.

Results and Discussion

The performance and carcass data for the steers in Study No. 1 are presented in Table 2. Average daily gain, total gain, and final weight were significantly ($P<.01$) higher for cattle in the lot with both fans and shade. These data are similar to those reported by Lofgreen (1969)

TABLE 2.—Results of Drylot Following Winter Grazing, Three-Year Average (May-September; 104 Days) 1966-68

Treatment	Fans & shade	Shade only
Lot No.	1	2
Number of animals/year[1]	17	17
Final weight, lb.	928[a]	899[b]
Initial weight, lb.	675	675
Gain per steer, lb.	253[a]	224[b]
Daily gain per steer, lb.	2.43[a]	2.15[b]
Total feed intake/hd./day, lb.	21.68	21.18
Concentrate intake/lb. gain, lb.	8.92	9.85
Carcass weight, lb.[2]	534	519
Dressing per cent[3]	60.11	60.34
Starting feeder grade	9.54	9.78
Carcass grade	11.18	11.04
Fat thickness, inches	.35	.39
Yield grade	2.50	2.52
Ribeye muscle area, sq. in.	10.12	10.15

[1] Three steers from each lot were removed after 67 days and slaughtered. Data based on 14 steers in each lot that completed 104-day trial.

[2] Carcass weight is warm weight less 2% shrinkage.

[3] Dressing per cent is 2% less than warm weight divided by weight prior to slaughter.

[ab] Means on the same horizontal line with different superscripts are significantly ($P<.01$) different.

regarding use of fans to increase air flow in wooden corrals. However, Lofgreen did not find an increase in performance for cattle fed in wire pens when fans were used. He indicated that there is little to be gained by increasing air flow above 3 m.p.h. This suggests that natural air movement in this study was less than required, and that the addition of fans increased air movement to 3 m.p.h. or higher. The fans did not appear to affect total feed intake, concentrate required per pound of gain, or carcass traits.

Six steers, three from each lot, were selected each year for slaughter after 67 days on feed to determine fat color and grade. It was of interest to note the rate of fattening and the time required for carcasses of grass-fed cattle to bleach out when placed in the drylot on concentrate feeds. The cattle appearing the fattest by visual evaluation were selected for slaughter at this time. Based on three years' data, cattle fed for 67 days exhibited acceptable fat color (white) in the carcasses. The three cattle in the lot with fans gained 0.84, 0.46, and 0.81 of a pound per day more than those without fans for 1966, 1967, and 1968, respectively. The cattle in the lot with fans also had significantly higher carcass grades than those in the lot without fans.

It was also of interest to note, according to weigh periods, that the fans had little effect on animal performance when the nights began to cool in August and September. During the latter feeding periods cattle in the shaded lot without fans tended to compensate for their poorer performance earlier.

STUDY NO. 2 (PHASE 2)

This study was designed to compare animal performance for grazing and green chop trials with and without concentrates. Cattle were obtained from Phase 1 following a 134-day ryegrass grazing period.

Forage crops for grazing and green chop were prepared in the following manner:

Grazing—Twenty-four acres were disked twice in May. At the time of planting, 210 pounds of 6-24-24 and 190 pounds of ammonium nitrate were applied. During the growing season ammonium nitrate was applied twice as a top-dressing at the rate of 150 pounds per acre. In July of 1966 and 1967 it was necessary to irrigate nine acres by sprinkling with two inches of surface water.

Green Chop—Ten acres in 1966, 12 in 1967, and 18 in 1968 were disked twice in April. One-third of the land was seeded in late April or early May with 35 pounds of Lindsey 77F per acre and cultipacked. The remaining two-thirds of the land was seeded each year in three-acre plots at weekly intervals. In 1966 and 1967 trials, 450 pounds of ammonium nitrate per acre was applied as a top-dressing during the growing season in three applications of 150 pounds each. During these two years, six inches of surface water was applied per acre by sprinkling in three applications of two inches each. In 1968, 300 pounds of ammonium nitrate was applied per acre as a top-dressing in two applications of 150 pounds each. Plots were not irrigated in the 1968 trial.

Forage samples were collected each week and pooled by months to measure changes in chemical composition. Samples were randomly selected from each plot and analyzed for crude protetin, crude fiber, ether extract, and ash.

Results and Discussion

Chemical composition data of forages used for grazing and green chop are presented in Table 3. In general, there were only slight differences in chemical composition between the forages. The composition did not appear to change between months. There was a tendency for samples of forage from grazing to be lower in fiber, which may account for the poorer performance of cattle fed green chop (Table 4). In feeding green chop the whole plant is fed, whereas grazing animals are selective and consume the more palatable parts of the plant which are generally more nutritious.

TABLE 3.—Chemical Composition of Forage Used for Grazing and Green Chop

Component	Crude protein	Crude fat	Crude fiber	Ash
	%			
June				
Grazing	8.97	2.40	30.50	6.75
Green chop	7.76	2.07	32.52	7.28
July				
Grazing	9.75	2.40	29.73	8.90
Green chop	9.81	2.57	31.11	7.35
August				
Grazing	8.07	2.10	31.75	7.23
Green chop	9.05	2.55	30.75	7.39
September				
Grazing	8.52	1.78	29.63	9.91
Green chop	8.53	2.08	30.48	7.46

Results of animal performance for grazing and green chop trials with and without concentrates are presented in Table 4. Grazing and green chop alone produced fewer pounds of gain than when concentrates were added to the treatments. However, the difference between grazing alone and green chop with concentrates was not statistically significant. Green chop fed alone resulted in the lowest rate of gain, while grazing with concentrates produced the highest rate of gain. Wise *et al.* (1965) reported similar data and concluded that the green chop method of fur-

TABLE 4.—Effects of Concentrates Versus No Concentrates on Grazing and Green Chop, Three-Year Average (81 Days) 1966-68

Treatment	Grazing	Green chop	Grazing + concentrates	Green chop + concentrates
Lot. No.	1	2	3	4
No. of animals/year	18	18	18	18
Final wt., lb.	798^a	751^b	828^c	808^a
Initial wt., lb.	657	667	656	661
Gain per steer, lb.	141^a	84^b	172^c	147^a
Daily gain per steer, lb.	1.74^a	1.04^b	2.12^c	1.81^a
Concentrate int./hd./day, lb.			6.57	6.57
Concentrate int./lb. gain, lb.			3.10^a	3.63^b
Green forage int./hd./day, lb.		86.32^a		68.61^b
Dry matter forage/hd./day, lb.		21.32^a		16.95^b
Av. dry matter in forage, %	26.15	24.70^b	26.15*	24.70
Time for cutting forage, min.		30		30

*Two-year average only, 1967-68.

^{abc}Means on the same horizontal line with different superscripts are significantly ($P<.05$) different.

nishing forage to fattening steers had limited application in the Southeastern United States. Their conclusions were reached after analyzing both economic and animal performance data which showed that labor and harvesting costs were too great for profitable returns.

These data suggest that green chop alone did not provide sufficient energy for fattening. When 6.57 pounds of concentrates (or 1 per cent of the body weight) were added, gain was increased significantly. The same was noted in the grazing treatments. Cattle in the group grazing and receiving concentrates were more efficient in concentrate conversion, requiring only 3.10 pounds of feed per pound of gain, as compared with 3.63 pounds of feed per pound of gain for the group receiving green chop and concentrates.

Consumption of green chop alone was significantly greater than consumption of green chop with concentrates, but animals in the latter group gained faster and were more efficient. Intake of green chop was probably limited by fill, whereas cattle fed green chop with concentrates consumed feed according to energy requirements. The same analogy can be presented for the groups grazing and grazing with concentrates; however, through selective grazing, the cattle not receiving concentrates tended to compensate or balance their diet, thus accounting for the small differences between the two groups. These data support previous reports by Carpenter *et al.* (1968) that the performance of grazing cattle can be improved by feeding concentrates in addition to grazing.

PHASE 3

Drylot Fattening Following Grazing and Green Chop

Carpenter *et al.* (1968) have shown that cattle can be economically finished to slaughter weights of 900 to 1,000 pounds with grazing and concentrates fed at 1 per cent of body weight. This phase of the study was designed to compare the performance of steers on green chop plus concentrates and grazing plus concentrates with that of cattle fed a full-feed of concentrates in drylot.

Procedure

Cattle in Phase 2 that received concentrates with green chop and concentrates with grazing were continued on their treatments for an additional 48 days. The cattle that were grazed and fed green chop without concentrates were placed in the drylot and fed the experimental ration presented in Table 1 for 55 days and slaughtered.

Results and Discussion

Feedlot and carcass data for this phase of the study are presented in Table 5. Cattle fed in drylot gained significantly faster than those fed concentrates with grazing and green chop. Cattle on the previous treatment of green chop without concentrates gained significantly faster and were slightly more efficient in feed conversion than those grazed without concentrates. The higher performance in this phase was probably due to compensatory gain and different starting weights, since the cattle fed green chop were lighter. Peacock *et al.* (1964) reported that daily gains during a 140-day drylot period were inversely related to winter gains. Cattle in Lots 3 and 4 decreased in daily gains in Phase 3, even though they consumed higher levels of concentrates. This was a result of increased maintenance requirements with increased body weight, and possibly a decrease in forage quality in the latter phases of the grazing period. It should also be noted that concentrate-supplemented cattle gained significantly faster in Phase 2, which tended to decrease performance in Phase 3.

Cattle fed in drylot were heavier at slaughter, and had a higher dressing per cent. There were no significant differences between treatments for carcass grade, fat thickness, yield grade, or ribeye area.

In the 1966 trial, yellow fat color was noted in 11 of the 72 carcasses, but was not observed during the other trials. The distribution of carcasses into grades for the three years is presented in Table 6. Cattle grazed and fed in drylot produced the greatest number of carcasses in the higher grades, whereas those fed concentrates with green chop accounted for the lowest grading carcasses. Since energy consumption is related to car-

TABLE 5.—Results of Green Chop and Grazing with Concentrates and Drylot Finishing Following Green Chop or Grazing, Three-Year Average, 1966-68

Treatment	Drylot	Drylot	Grazing + concentrates	Green chop + concentrates
Previous treatment	Grazing	Green chop	Same	Same
Lot No.	1	2	3	4
No. of animals/trial	18	18	18	18
No. of days	55	55	48	48
Final wt., lb.	915[a]	881[b]	901[a]	868[b]
Initial wt., lb.[1]	798	751	828	808
Gain per steer, lb.	117[a]	130[a]	73[b]	60[b]
Daily gain per steer, lb.	2.13	2.36	1.52	1.25
Daily feed int./hd./day, lb.	23.82	23.82	8.38	8.38
Concentrate int./lb. gain, lb.	11.18[a]	10.09[a]	5.51[b]	6.70[b]
Green forage int./hd./day, lb.				70.13
Dry matter forage/hd./day, lb.				19.99
Av. dry matter forage, per cent			31.05[a]	28.50[b]
Time for cutting forage, min.				30
Carcass wt., lb.[2]	516	496	495	474
Dressing per cent[3]	59.09[a]	58.89[a]	56.99[b]	56.20[b]
Carcass grade	9.75	9.94	9.57	9.18
Fat thickness, inches	.29	.26	.29	.23
Yield grade	2.36	2.33	2.40	2.23
Ribeye muscle area, sq. in.	9.35	9.30	9.38	9.20

[1] All values are expressed, where applicable, as averages. All gains are calculated on a basis of from 12 to 16 hours without water.

[2] Carcass weight is warm weight less 2% shrinkage.

[3] Dressing per cent is warm weight less 2% divided by weight prior to slaughter.

[ab] Means on the same horizontal line with different superscripts are significantly ($P < .05$) different.

TABLE 6.—Carcass Grades for Cattle Fed During the Three-Year Period

Treatment	Grade						
	Choice	Choice–	Good+	Good	Good–	Standard+	Standard
Drylot (grazing)	3	1	5	39	3	1	2
Drylot (green chop)	1	1	7	32	12	0	1
Grazing + concentrates	1	0	3	31	14	0	5
Green chop + concentrates	2	1	2	21	13	4	11

cass grade through its effect on the degree of marbling, these data suggest that green chop did not provide sufficient energy to produce marbling. This is more evident when comparing Lot 3 with Lot 4. The former group produced carcasses similar to those in the drylot group (green chop), indicating that animals being grazed tend to balance their energy intake through selective grazing.

It is also of interest to note that during the last 48 days, the green chop area supported 2.66 steers per acre and the grazing area 1.17 steers per acre. During this period of each trial, approximately one-half of the grazing area was crabgrass and Brachiaria. This supports earlier statements that even though more forage may be produced from an area, adequate performance cannot be expected unless the forage contains sufficient energy to meet requirements for fattening.

A summary of performance for the four treatments during the 270-day period is presented in Table 7. These data show green chop treatments produced the lowest gains and carcass performance. This suggests that green chop, when cut and fed to the animal, contains insufficient energy. It appears that grazing without concentrates, followed by a drylot period, is equivalent to grazing with concentrates fed at 1 per cent of body weight. Green chop treatments with concentrates and alone were inferior to the other treatments. This suggests that green chop, when fed under the conditions of this study, will not produce the desired performance.

TABLE 7.—Summary of Performance for the Four Treatments (270 days)

Treatment	Drylot (grazing)	Drylot (green chop)	Grazing + concentrates	Green chop + concentrates
Gain/steer, lb.	463	429	451	419
Av. daily gain	1.71	1.59	1.71	1.58
Carcass grade	9.35	9.30	9.38	9.20

SUMMARY

Studies at the Northeast Louisiana Experiment Station have shown that slaughter cattle weighing 900 to 1,000 pounds can be produced using a combination of forage crops with concentrates, or without concentrates when followed by a short drylot feeding period. These carcasses, with a thin rind of external fat and sufficient quality to grade U.S. Good to Choice, have been highly acceptable to packers.

The work reported here was conducted to study various methods available to the producer, using a maximum of temporary grazing crops and a minimum of concentrates, for producing slaughter steers. The study was conducted at the Macon Ridge Branch Experiment Station, Winnsoboro, Louisiana, during 1966-1968.

The over-all study was divided into three phases. Phase 1 consisted of winter-grazing 106 beef steers on ryegrass pasture for 134 days. Phase 2 involved two studies. Study No. 1 consisted of a drylot program with 34 steers following ryegrass grazing. The steers were divided into treatments designed to study the effect of shade with and without fans on feedlot performance during summer feeding periods. Study No. 2 of Phase 2 involved a comparison of grazing and feeding green chop, both with and without concentrates. Phase 3 was designed to compare the performance of steers fed green chop with concentrates and grazing with concentrates, with that of cattle fed a full-feed of concentrates in drylot.

In Phase 1, steers gained 234 pounds during a 134-day grazing period, for a daily gain of 1.75 pounds. This resulted in the production of 351 pounds of beef per acre. There was an abundance of forage available each year. Pastures were stocked at the rate of 1.5 steers per acre.

In Study No. 1 of Phase 2, cattle in the lot with both fans and shade had a higher daily gain, total gain, and final weight. Fans did not improve feed intake, concentrate required per pound of gain, or carcass traits.

Cattle in the second study of Phase 2 were grazed and fed green chop with and without concentrates for 81 days. Grazing and green chop alone produced fewer pounds of gain than when concentrates were added to the treatments. Green chop fed alone resulted in the lowest gain, while grazing with concentrates produced the highest daily gain. It was concluded that green chop alone did not provide sufficient energy to promote adequate performance since cattle grazing the same forage used for green chop had significantly higher daily gains. These data indicate that through selective grazing the cattle tended to balance their diet with the more nutritious portions of the plants, whereas cattle fed green chop alone were required to consume the total plant.

In Phase 3, cattle previously grazed and those fed green chop, with no concentrates, were fed in drylot for 55 days. Cattle that grazed and those fed green chop, with concentrates, were maintained in their respective groups for an additional 48 days. Cattle fed in drylot gained faster than those fed concentrates with grazing and green chop. Cattle on the previous treatment of green chop alone gained faster and were slightly more efficient in feed conversion than those previously grazed without concentrates. Cattle gaining least on previous treatments compensated for their poor performance and gained faster in the latter period. Steers fed in drylot were heavier at slaughter and had a higher dressing per cent. There were no apparent differences between treatments for carcass grade, fat thickness, yield grade, or ribeye area.

When considering the total feeding period (270 days), the cattle grazed with concentrates and those fed in drylot following grazing had a daily gain of 1.71 pounds per day, while the cattle fed green chop with concentrates and those fed in drylot following green chop gained approximately 1.60 pounds per day (Table 7).

Data in these studies indicate that green chop will not yield the performance obtained by grazing animals. In addition, economic limitations restrict the use of green chopping since this method requires that forage be harvested daily. Based on these data, green chopping appears to have limited application under the conditions imposed in these studies.

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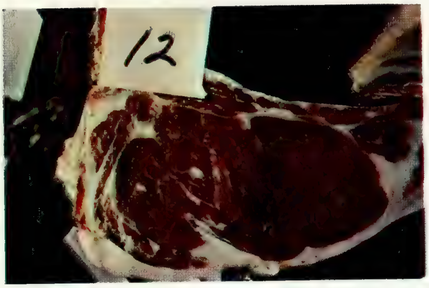
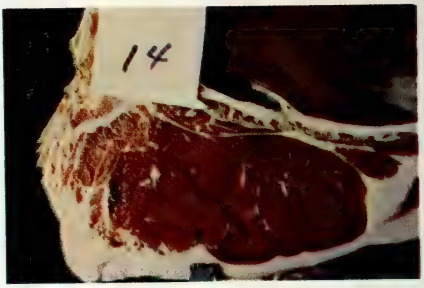
(See back cover page for rib pictures from the various treatments.)

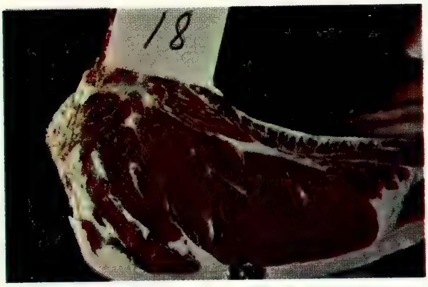
12th Rib from the Various Treatments



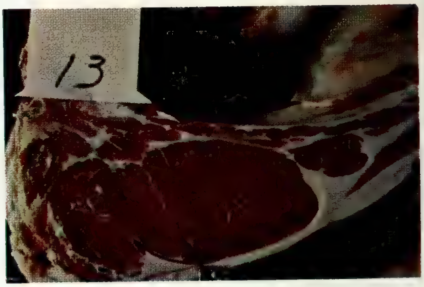
Fans and shade in drylot
(Lot 1, Phase 2)



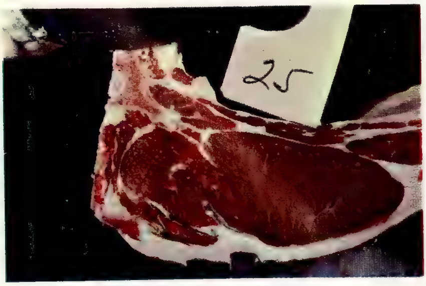
Shade only in drylot
(Lot 2, Phase 2)



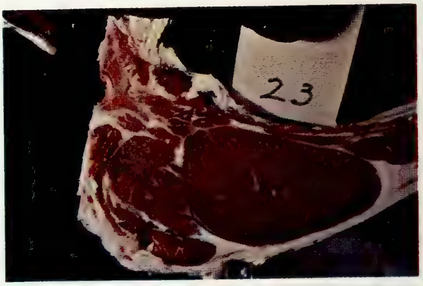
Fed in drylot after grazing
(Lot 1, Phase 3)



Fed in drylot after green chop
(Lot 2, Phase 3)



Grazing and grain
(Lot 3, Phase 3)



Green chop and grain
(Lot 4, Phase 3)

67
E36

Fertility Levels and Lime Status of Soils in Louisiana

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Fertility Levels and Lime Status Of Soils in Louisiana

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W. J. Peevy and W. H. Willis[1]

INTRODUCTION

Soil tests are now widely accepted as a reliable diagnostic technique in evaluating the fertility level and lime status of soils. Soil tests serve as a guide for making suggestions for plant-nutrient element additions for correcting deficiencies or maintaining adequate plant-nutrient levels in soils for sustained high-level production.

Soil test summaries provide information on the fertility level and lime status of soils. They may be used to indicate changes in levels of plant nutrients that occur over a period of time and may also be used to delineate soils and areas where additional emphasis should be placed in developing sound fertility programs. However, soil test summaries do not indicate the lime status and fertility level of a specific soil. In order to obtain specific information, it is necessary to test representative soil samples of individual fields or small areas within a field.

The data presented in this publication are a compilation of results of 37,155 soil tests on soil samples submitted by farmers to the Agricultural Experiment Station Soil Testing Laboratory for chemical analysis between January 1, 1964, and December 31, 1967. Soil test results from samples from lawns, gardens, and greenhouses are not included in the summary. Soil reaction (pH), extractable calcium, magnesium, potassium, and phosphorus are summarized according to parish and general soil area.

The primary objective of this publication is to present in summary form the fertility level and lime status of major soil areas in each parish in Louisiana.

SOIL SAMPLE DISTRIBUTION

The number of soil samples and the per cent of the total number summarized from the eight soil areas (see soil area map, pages 60 and 61) are presented in Table 1. The total number of samples summarized ranged from a high of 8,353 from the Mississippi River Alluvial area, representing 23 per cent of the total, to a low of 1,538 from the Loessial Hill area, representing 4 per cent of the total. The samples from the Coastal Plain, Flatwoods, and Alluvial soils of the Ouachita River and Red River comprised 12, 13, 11, and 11 per cent of the total, respectively.

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Table 1.-The number of soil samples and the per cent of the total number summarized from the eight soil areas in Louisiana. 1964-1967.

General Soil Area	Number of samples	Per cent of total
Mississippi River Alluvial Soils	8353	23
Mississippi Terraces	7158	19
Flatwoods	4803	13
Coastal Plain	4603	12
Alluvial soils of the Red River	4119	11
Alluvial soils of the Ouachita River	4005	11
Coastal Prairies	2576	7
Loessial Hills	1538	4
TOTAL	37,155	100

Nineteen and 7 per cent of the total number of samples analyzed were from the Mississippi Terraces and Coastal Prairie area, respectively.

The number of soil samples included in the summary is presented in Table 2 by parish. Sixty per cent of the samples submitted to the laboratory for analysis were received from the following parishes: Tangipahoa, Morehouse, Franklin, West Carroll, St. Mary, Caddo, Richland, Avoyelles, Iberia, Rapides, St. Tammany, Ouachita, St. Landry, Acadia, Natchitoches, and Washington. More than 1,000 soil samples were summarized from each of these parishes. Fewer than 100 samples were received from each of Bienville, Cameron, Claiborne, Jackson, Jefferson, Orleans, Plaquemines, St. Bernard, St. Charles, St. John, Union, and Webster Parishes.

PROCEDURES

For this summary the soil samples were grouped according to parish, General Soil Area, and textural classification. The soil samples were placed into one of the following soil areas: (1) Alluvial soils of the Red River, (2) Mississippi River Alluvial Soils, (3) Alluvial soils of the Ouachita River, (4) Mississippi Terraces, (5) Loessial Hills, (6) Coastal Prairies, (7) Flatwoods, and (8) Coastal Plain. The General Soil Areas are shown on the map on pages 60 and 61. The morphological characteristics of the soils that are representative of each of the General Soil Areas are discussed in Louisiana Agricultural Experiment Station Bulletin No. 631 (*4*).[1]

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[1] Italic numbers in parentheses refer to Literature Cited, page 120.

Table 2.-The number of soil samples summarized by each parish in Louisiana. 1964-1967.

Parish	No. of Samples	Parish	No. of Samples
Acadia	1049	Morehouse	1938
Allen	338	Natchitoches	1043
Ascension	432	Orleans	6
Assumption	715	Ouachita	1099
Avoyelles	1223	Plaquemines	76
Beauregard	333	Pointe Coupee	529
Bienville	16	Rapides	1161
Bossier	479	Red River	517
Caddo	1235	Richland	1240
Calcasieu	356	Sabine	123
Caldwell	460	St. Bernard	16
Cameron	83	St. Charles	32
Catahoula	592	St. Helena	545
Claiborne	12	St. James	199
Concordia	331	St. John	44
DeSoto	395	St. Landry	1068
E. Baton Rouge	576	St. Martin	428
E. Carroll	260	St. Mary	1381
E. Feliciana	457	St. Tammany	1149
Evangeline	693	Tangipahoa	3564
Franklin	1722	Tensas	455
Grant	635	Terrebonne	146
Iberia	1207	Union	19
Iberville	518	Vermilion	552
Jackson	28	Vernon	132
Jefferson	22	Washington	1035
Jefferson Davis	504	Webster	4
Lafayette	325	W. Baton Rouge	131
Lafourche	264	W. Carroll	1409
LaSalle	106	W. Feliciana	391
Lincoln	347	Winn	123
Livingston	384		
Madison	503	TOTAL	37,155

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In this investigation, the soil was placed into one of three textural categories: coarse, medium, and fine. Sand, loamy sand, sandy loam, and fine sandy loam are considered coarse-textured soils. Medium texture includes very fine sandy loam, silt loam, and loam. Sandy clay loam, silty clay loam, silty clay, clay loam, and clay are the fine-textured soils.

The results of the soil tests were divided into six ranges for soil reaction (pH), and four ranges each for calcium, magnesium, potassium, and phosphorus. The six ranges used for summarizing the soil test results for pH are: < 4.9, 5.0-5.4, 5.5-5.9, 6.0-6.4, 6.5-6.9, and > 6.9. The four ranges used for summarizing the results of soil tests for calcium, magnesium, potassium, and phosphorus are presented in Table 3.

The analytical methods and procedures used to determine the fertility level and lime status of the soil samples are described in Louisiana Agricultural Experiment Station Bulletin No. 632 (*1*). Soil reaction

Table 3.-The ranges used to summarize soil test results.

Soil Area	Soil Texture	CEC meq/100g	Nutrient Element	Ranges			
				1	2	3	4
				parts per million			
Coastal Plain Soils	Coarse and medium	2-6	Ca	< 300	300-500	500-1000	> 1000
			Mg	< 30	30-50	50-100	> 100
			K	< 80	80-120	120-160	> 160
			P	< 40	40-80	80-120	> 120
Flatwoods Soils	Coarse and medium	4-8	Ca	< 400	400-800	800-1600	> 1600
			Mg	< 40	40-80	80-160	> 160
			K	< 80	80-120	120-160	> 160
			P	< 35	35-70	70-105	> 105
Miss. Terraces and Loessial Hills	Coarse and medium	6-12	Ca	< 500	500-1000	1000-2000	> 2000
			Mg	< 50	50-100	100-200	> 200
			K	< 100	100-150	150-200	> 200
			P	< 55	55-110	110-165	> 165
Coastal Prairie	Coarse, medium and fine	8-15	Ca	< 600	600-1200	1200-2400	> 2400
			Mg	< 60	60-120	120-240	> 240
			K	< 100	100-150	150-200	> 200
			P	< 35	35-70	70-105	> 105
Alluvial Soils of the Red, Ouachita, and Miss. Rivers	Coarse and medium	8-15	Ca	< 700	700-1400	1400-2800	> 2800
			Mg	< 70	70-140	140-280	> 280
			K	< 110	110-165	165-220	> 220
			P	< 60	60-120	120-180	> 180
Alluvial Soils of the Red, Ouachita, and Miss. Rivers	Fine	> 15	Ca	< 1400	1400-2800	2800-4000	> 4000
			Mg	< 140	140-280	280-450	> 450
			K	< 160	160-240	240-320	> 320
			P	< 80	80-160	160-240	> 240

(pH) was determined by using a pH-meter and a slurry of soil and distilled water at a soil-to-water ratio of approximately 1:1. Phosphorus was determined by extracting a sample of soil with a solution of 0.10 normal hydrochloric acid containing 0.03 normal ammonium fluoride. A soil-to-solution ratio of 1:20 and an extracting period of 15 minutes were used to determine extractable phosphorus. Potassium, calcium, and magnesium were determined by extracting a sample of soil with a 0.10 normal hydrochloric acid solution using a soil-to-solution ratio of 1:20. The extraction time was 15 minutes.

DISCUSSION OF RESULTS

Soil Reaction (pH)

The pH status of the soils in each of the eight soil areas is presented in Tables 4A-11A, and in each parish in Tables 12A-75A. The data in Table 4A indicate that 56 per cent of all soil samples from the Alluvial area of the Red River were neutral to alkaline in reaction. Only 9 per cent of the soil samples tested from this area had pH values below pH 6.0. Soils that were slightly to moderately acid in reaction are the older highly weathered soils that occur predominantly in the southern part of the Red River Alluvial area. The data in Table 60A indicate that 48 per cent of the samples analyzed from the Red River Alluvial area in St. Landry Parish had reactions below pH 6.0. Soils located in the Red River Alluvial area that were acid in reaction also occur adjacent to Bayou Pierre in Caddo, DeSoto, Red River, and Natchitoches Parishes and near local stream bottoms and old bayous in Bossier, Red River, and Grant Parishes east of the Red River.

Some soils from areas of the Mississippi River Alluvium were also neutral to alkaline in reaction. The soil test summary data presented in Table 5A indicate that 12 per cent of the samples submitted to the laboratory for analysis from this area had pH values above 6.9. Forty-two per cent of all samples analyzed from the Mississippi River Alluvial area had pH values below 6.0. Fifteen per cent of all samples from the Alluvial area of the Mississippi River had pH values below 5.5. By comparing the results of this investigation with soil test summary data collected 10 years earlier (5), it appears that certain alluvial soils of the Mississippi River Flood Plain are becoming more acid. The increase in soil acidity may be due to the use of acid-forming fertilizers, crop removals of bases, and leaching losses of calcium, magnesium, potassium, and sodium.

Soils occurring in all areas other than those in the Mississippi and Red River Alluvial areas were considerably more acid in reaction. Sixty per cent of all soil samples from the Loessial Hill, Mississippi Terrace, Flatwoods, Coastal Prairie, Coastal Plain, and Ouachita River Alluvial areas had pH values below 6.0. The percentage of samples testing below pH 6.0 ranged from 72 per cent for soils from the Loessial Hill area (Table 8A) to 53 per cent for those from the Ouachita River Alluvial and Coastal Plain areas (Tables 6A and 11A). Thirty-five per cent of all samples from these areas had pH values below 5.5.

There is a critical need for additions of limestone to adjust the reaction of acid soils for the growth of certain crops in the Loessial Hill, Mississippi Terrace, Flatwoods, Coastal Prairie, Coastal Plain, and Alluvial soils of the Ouachita River areas. The pH status of some alluvial soils of the Mississippi River also shows a need for lime. Soil test summary data presented in Tables 24A, 61A, 65A, 26A, and 34A indicate that from 49 to 78 per cent of the soil samples from the Mississippi River Alluvial area in Catahoula, St. Martin, Tensas, Concordia, and Iberia Parishes had pH values below 6.0. Samples testing below pH 6.0 ranged from 78 per cent for the Mississippi River Alluvial soils from Catahoula Parish to 49 per cent for those from Iberia Parish.

Extractable Calcium

The evaluation of the calcium status of soils, whether it be for deficiency or its association with pH or nutrient balance, or the kind of lime to use, has been investigated for many years. The problem is complicated by the enormously varying needs of plants for calcium as a nutrient element, the soil reaction, and the relationships between calcium and other elements present in the soil.

Under "ideal" conditions, the exchangeable calcium in the soil should vary between 60 and 85 per cent of the cation exchange capacity, depending upon the textural class (*3*). The percentages of soil samples occurring in ranges 1 and 2, presented in Table 3, are considered to be low in extractable calcium. Soils occurring in these two ranges are frequently less than 60 per cent saturated with calcium.

The calcium status of the soils in each of the eight soil areas is presented in Tables 4B-11B, and in each of the parishes in Tables 12B-75B. Soil test summary data indicate that 36 per cent of the samples from the Alluvial area of the Red River and 41 per cent of those from the Alluvial area of the Mississippi River were low in extractable calcium. The data in Tables 33B, 52B, 60B, 34B, and 61B indicate that over 50 per cent of the samples from the Alluvial areas of Grant, Red River, St. Landry, Iberia, and St. Martin Parishes were low in extractable calcium.

The data presented in Tables 6B, 7B, 8B, and 9B indicate that over 75 per cent of the soil samples from the Ouachita River Alluvial, Mississippi Terrace, Loessial Hill, and Coastal Prairie areas were low in extractable calcium. Sixty-eight per cent of the soil samples from the Flatwoods area (Table 10B) and 54 per cent of those from the Coastal Plain area (Table 11B) were also found to be low in extractable calcium.

Extractable Magnesium

According to Thompson (*6*), humid-region soils should contain approximately five times as many milliequivalents of exchangeable calcium as exchangeable magnesium. All ranges for magnesium presented in Table 3 are based on a Ca:Mg ratio of approximately 5:1 on a chemical equivalent basis or a 10:1 ratio expressed as parts per million. Unpublished data on file in the Department of Agronomy show that alluvial soils in the Red and Mississippi River areas have a Ca:Mg ratio of about

6.5:1 expressed as parts per million. Soils in all other soil areas have considerably lower Ca:Mg ratios. The percentages of soil samples occurring in ranges 1 and 2 are considered to be relatively low in extractable magnesium.

It has been demonstrated that on the sandy soils in the Coastal Plain areas of Louisiana, a response by clover to applications of magnesium was obtained if the amount of dilute acid extractable or exchangeable magnesium was less than 55 parts per million (*2*).

The magnesium status of the soils in each of the eight soil areas is presented in Tables 4C-11C, and in each of the parishes in Tables 12C-75C. The alluvial soils of the Red and Mississippi Rivers ordinarily contain high amounts of extractable magnesium. The data in Tables 4C and 5C indicate that only 2 per cent of the soil samples from the Alluvial area of the Red River and 3 per cent of those from the Alluvial area of the Mississippi River were low in extractable magnesium. The alluvial soils derived from older sediments of the Ouachita River and distributaries of the Arkansas River generally contain lower amounts of extractable magnesium than do the alluvial soils derived from recent sediments of the Red and Mississippi Rivers. Soil test summary data presented in Table 6C indicate that 24 per cent of the alluvial soils of the Ouachita River were low in extractable magnesium.

The data presented in Tables 7C, 11C, and 9C indicate that 11 per cent of all soil samples from the Mississippi Terrace area, 14 per cent of those from the Coastal Plain area, and 17 per cent of those from the Coastal Prairie area were low in extractable magnesium. Soils representative of the Coastal Plain area in Bienville, Red River, and Vernon Parishes and soils of the Coastal Prairie area in Allen, Calcasieu, Evangeline, and Jefferson Davis Parishes had the highest percentage of samples testing low in magnesium. Soil test summary data presented in Tables 52C, 69C, and 18C indicate that 27 per cent of the soil samples from the Coastal Plain areas of Red River and Vernon Parishes and 32 per cent of those from Bienville Parish were low in magnesium. The data presented in Tables 31C, 38C, 21C, and 13C indicate that 25 per cent of the soil samples from the Coastal Prairie area in Evangeline Parish, 27 per cent of those from Jefferson Davis Parish, 33 per cent of those from Calcasieu Parish, and 55 per cent of the samples from the Coastal Prairie area of Allen Parish were low in extractable magnesium.

Imperfectly drained soils from the Flatwoods areas of the state occur predominantly in two major sections, as shown on the map on pages 60 and 61. The largest areas occur in southwestern and southeastern Louisiana. The data in Table 10C show that 21 per cent of all soil samples from the Flatwoods areas were low in magnesium. The soils in the Flatwoods area in southwestern Louisiana were consistently lower in magnesium than those occurring in the southeastern part of the state. Over 30 per cent of the soil samples from the Flatwoods area of southwest Louisiana were low in magnesium. Nineteen per cent of the samples from the Flatwoods area of southeast Louisiana were low in magnesium.

The Loessial Hills are located in the southeastern part of the state;

they extend from the bluffs of the Mississippi River eastward and occur in West Feliciana, East Feliciana, St. Helena, Tangipahoa, and Washington Parishes. The hills are made up of wind-blown silty materials usually underlain by sand or sandy clay. Due to past cropping practices, cultivated slopes are moderately to severely eroded. It may be noted in Table 8C that 74 per cent of the soil samples from the Loessial Hill area were designated as coarse textured. Thirty-seven per cent of the soil samples from this area contained less than 100 parts per million of magnesium.

On acid soils that are low in extractable magnesium, dolomitic lime should be used to correct the acidity and to supply magnesium and calcium. If lime is not needed and magnesium is low, soluble sources of magnesium, such as magnesium sulphate or sulphate of potash-magnesia, may be applied.

A critical need for lime additions exists on many soils in Louisiana to correct soil acidity or to supply calcium and/or magnesium. If a profitable and competitive system of agricultural production is carried out, a sound liming program demands top priority. The need for lime should be based on soil reaction, extractable calcium and magnesium, and chemical measurements calibrated to determine lime needs.

Extractable Potassium

The ranges used in summarizing soil test results for potassium presented in Table 3 are based primarily on the cation exchange capacity, the degree of potassium saturation, and the textural class of the soil. Approximately 5 to 7 per cent of the total cation exchange capacity of coarse-textured soils should be saturated with potassium. Only about 3 to 5 per cent of the exchange complex of medium- and fine-textured soils should be saturated with potassium for the soils to supply adequate potassium for growing crops.

The potassium status of the soils in each of the eight soil areas is presented in Tables 4D-11D, and in each of the parishes in Tables 12D-75D. Soil samples falling into range 1 presented in Table 3 are considered to be low in extractable potassium.

The data in Tables 4D-6D indicate that 20 per cent of all soil samples from the Alluvial area of the Red River and 28 per cent of those from the Alluvial area of the Ouachita River were low in extractable potassium. Thirty-seven per cent of the soil samples from the Alluvial area of the Mississippi River were low in potassium.

Alluvial soils of the Red River in St. Landry and DeSoto Parishes had higher percentages of samples testing low in potassium than did the other parishes in this soil area. The data in Table 60D indicate that 34 per cent of the soil samples from the Alluvial area of the Red River in St. Landry Parish were low in potassium. Thirty-two per cent of the samples from the Alluvial area of the Red River in DeSoto Parish were also low in extractable potassium (Table 27D).

Alluvial soils of the Ouachita River in Caldwell and Richland Parishes had a higher percentage of samples testing low in potassium than did alluvial soils in the other parishes in this soil area. The data in

Tables 22D and 53D show that 39 per cent of the samples from Caldwell Parish and 34 per cent of those from Richland Parish were low in extractable potassium.

Some soils occurring in the Mississippi River Alluvial area had a higher percentage testing low in potassium than is indicated by the average percentage of samples testing low for the whole area. The parishes with the highest percentages of soils testing low in extractable potassium in the Mississippi River Alluvial area were: Iberia, 70 per cent; St. Mary, 67 per cent; Lafayette, 53 per cent; St. James, 49 per cent; St. Martin, 45 per cent; and Terrebonne, 45 per cent.

The data presented in Tables 7D, 10D, and 11D indicate that the percentages of all soil samples from the Mississippi Terrace, Flatwoods, and Coastal Plain areas that tested low in potassium were 37, 39, and 40, respectively. Over 50 per cent of the soil samples from the Mississippi Terrace area in Ascension, East Baton Rouge, Iberia, Livingston, Lafayette, and Evangeline Parishes were low in extractable potassium. The percentage of soil samples testing low from this area ranged from 51 per cent in Evangeline Parish to 73 per cent in Ascension and East Baton Rouge Parishes. The low potassium content of the terrace soils in the six parishes previously mentioned may be due to the fertility and crop management practices followed in past years.

The potassium content of the soils from the Flatwoods area in the southwestern part of the state was considerably lower than that of the soils occurring in the southeastern part. Over 60 per cent of the soil samples from the Flatwoods area of southwest Louisiana were low in potassium. Only 35 per cent of those from southeast Louisiana were low in potassium. Past cropping and fertilization practices probably account for this difference in the potassium content of these soils. Flatwoods soils in southeast Louisiana have been intensively managed for many years for the production of truck crops and pastures for dairy animals. In contrast, Flatwoods soils in the southwestern part of the state have been used for the production of rice, soybeans, and pastures for beef cattle, and consequently, fertilizer and lime use has not been intensive.

The data presented in Table 8D indicate that 50 per cent of all soil samples from the Loessial Hill area were low in extractable potassium. Many of these soils are moderately to severely eroded and are underlain at shallow depths by sandy materials which are generally lower in fertility than was the original silt loam material.

Soils of the Coastal Prairie area had a higher percentage of samples testing low in extractable potassium as compared with the soils representing the other seven soil areas. The data presented in Table 9D show that 66 per cent of the soil samples from the Coastal Prairie area were low in extractable potassium. Calcasieu Parish had a higher percentage of soils testing low in potassium than did the other parishes in the Coastal Prairie area, as well as the parishes in the other soil areas of the state. Soil test summary data presented in Table 21D indicate that 83 per cent of the samples from the Coastal Prairie area in Calcasieu Parish were low in extractable potassium.

Extractable Phosphorus

The phosphorus status of the soils in each of the eight soil areas is presented in Tables 4E-11E, and in each of the parishes in Tables 12E-75E. Soil samples falling into range 1 presented in Table 3 are considered to be low in extractable phosphorus.

The alluvial soils of the Red River generally contained relatively large amounts of extractable phosphorus. These soils were developed from sediments containing large amounts of phosphorus and other essential plant nutrients. Soil test summary data presented in Table 4E indicate that only 10 per cent of all samples from this area were low in extractable phosphorus. However, some soils occurring in the Red River Alluvial area had a higher percentage testing low in phosphorus than was indicated by the average percentage of soil samples testing low for the whole area. The data presented in Tables 27E and 60E indicate that 26 per cent of the Red River Alluvial soils in DeSoto Parish and 33 per cent of those in St. Landry Parish were low in extractable phosphorus. Many soils occurring in the Alluvial area of the Red River in DeSoto and St. Landry Parishes are more highly weathered; some were acid in reaction, and the general fertility status was lower than that of the other soils of the area. The percentages of samples testing low in phosphorus from the Red River Alluvial areas of Natchitoches, Red River, and Grant Parishes were 13, 15, and 19, respectively (Tables 46E, 52E, and 33E). Only 4 per cent of the samples from the Red River Alluvial area in Rapides Parish, 6 per cent of those in Avoyelles and Caddo Parishes, and 10 per cent in Bossier Parish tested low in phosphorus.

The data in Table 5E indicate that 31 per cent of all soil samples from the Alluvial area of the Mississippi River were low in extractable phosphorus. Older soils developed from Mississippi River alluvium deposited along Bayou Teche and its distributaries were considerably lower in extractable phosphorus than is indicated by the average of all soils located in the Mississippi River Alluvial area. These soils occur in the southcentral part of the state, and soil horizon development is more evident than in more recent alluvial sediments. The data presented in Tables 61E and 34E show that 82 per cent of the soil samples from the Alluvial area of the Mississippi River from St. Martin Parish and 76 per cent of those from Iberia Parish were low in extractable phosphorus. Over 50 per cent of the soil samples from the Mississippi River Alluvial areas of St. Mary, Lafayette, St. Landry, Catahoula, and Franklin Parishes were also found to be low in phosphorus (Tables 62E, 39E, 60E, 24E, and 32E).

Soils occurring in all areas of the state, other than those in the Alluvial areas of the Red and Mississippi Rivers, generally had a lower content of extractable phosphorus. Soil test summary data presented in Table 6E indicate that 41 per cent of all soil samples from the Alluvial area of the Ouachita River were low in extractable phosphorus. The percentages of samples testing low in phosphorus ranged from 29 per cent in Ouachita Parish to 68 per cent in Catahoula Parish. The parishes and percentage of the soils in the Ouachita River Alluvial area testing low in phosphorus were: Morehouse Parish, 42 per cent; Caldwell Parish, 46 per cent; Richland Parish, 47 per cent; and Franklin Parish, 62 per cent.

The data presented in Table 10E show that 37 per cent of all soil samples from the Flatwoods areas were low in extractable phosphorus. The relatively small percentage of the Flatwoods soils which tested low in phosphorus is probably due to the large amount of fertilizer used in the trucking area of the Flatwoods soils in the southeastern part of the state. Only 32 per cent of the samples from this section were low, whereas 63 per cent of the samples from the Flatwoods area in the southwestern part of the state were low in phosphorus.

The data presented in Table 11E show that 62 per cent of the soil samples from the Coastal Plain area were low in extractable phosphorus. The data in Tables 7E and 8E show that 64 per cent of all soil samples from the Mississippi Terrace and Loessial Hill areas were low in extractable phosphorus.

The highest percentage of soil samples testing low in phosphorus occurred in the Coastal Prairie area of southwest Louisiana. The data presented in Table 9E indicate that 78 per cent of all soil samples from this area were low in extractable phosphorus. The percentage of samples from the Coastal Prairie area which tested low in phosphorus ranged from 63 per cent in St. Landry Parish to 85 per cent in Acadia Parish. The low content of extractable phosphorus in Coastal Prairie soils may be due in part to the inherently low content of total phosphorus in the soil and soil conditions which govern the solubility of phosphorus. Since a majority of the soils in the Coastal Prairie area were acid in reaction, phosphorus has been rendered unavailable to most higher plants. Apparently, fertilizer use in this area has not altered the phosphorus level in the soils.

Table 4.-Summary of soil test results of soil samples from the Alluvial Area of the Red River. 1964-1967.

A. Soil Reaction (pH)

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
		< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Coarse	70	0	4	14	33	11	38
Medium	2268	0	3	8	15	13	61
Fine	1781	0	1	6	21	22	50
Average*		0	2	7	18	17	56

B. Extractable Calcium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 700	700-1400	1400-2800	> 2800
		parts per million			
Coarse	70	30	35	21	14
Medium	2268	11	26	25	38
		< 1400	1400-2800	2800-4000	> 4000
		parts per million			
Fine	1781	6	28	25	41
Average*		9	27	25	39

C. Extractable Magnesium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 70	70-140	140-280	> 280
		parts per million			
Coarse	70	0	7	43	50
Medium	2268	0	2	18	80
		< 140	140-280	280-450	> 450
		parts per million			
Fine	1781	0	2	5	93
Average*		0	2	13	85

D. Extractable Potassium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 110	110-165	165-220	> 220
		parts per million			
Coarse	70	27	41	16	16
Medium	2268	20	40	25	15
		< 160	160-240	240-320	> 320
		parts per million			
Fine	1781	20	34	27	19
Average*		20	37	26	17

E. Extractable Phosphorus

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 60	60-120	120-180	> 180
		parts per million			
Coarse	70	14	42	33	11
Medium	2268	6	21	41	32
		< 80	80-160	160-240	> 240
		parts per million			
Fine	1781	14	34	37	15
Average*		10	27	39	24

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 5.-Summary of soil test results of soil samples from the Alluvial Area of the Mississippi River. 1964-1967.

A. Soil Reaction (pH)

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
		< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Coarse	73	4	10	16	21	12	37
Medium	2372	3	13	25	27	15	17
Fine	5908	3	12	28	33	14	10
Average*		3	12	27	31	15	12

B. Extractable Calcium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 700	700-1400	1400-2800	> 2800
		parts per million			
Coarse	73	12	38	35	15
Medium	2372	5	22	59	14
		< 1400	1400-2800	2800-4000	> 4000
		parts per million			
Fine	5908	3	43	39	15
Average*		4	37	44	15

C. Extractable Magnesium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 70	70-140	140-280	> 280
		parts per million			
Coarse	73	4	7	30	59
Medium	2372	1	2	20	77
		< 140	140-280	280-450	> 450
		parts per million			
Fine	5908	1	2	13	84
Average*		1	2	15	82

D. Extractable Potassium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 110	110-165	165-220	> 220
		parts per million			
Coarse	73	21	16	27	36
Medium	2372	34	31	18	17
		< 160	160-240	240-320	> 320
		parts per million			
Fine	5908	38	29	18	15
Average*		37	29	18	16

E. Extractable Phosphorus

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 60	60-120	120-180	> 180
		parts per million			
Coarse	73	8	8	22	62
Medium	2372	24	15	16	45
		< 80	80-160	160-240	> 240
		parts per million			
Fine	5908	34	28	23	15
Average*		31	24	21	24

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 6.-Summary of soil test results of soil samples from the Alluvial Area of the Ouachita River. 1964-1967.

A. Soil Reaction (pH)

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
		< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Coarse	308	11	20	27	22	15	5
Medium	2702	5	17	25	29	19	5
Fine	995	23	25	21	16	10	5
Average*		10	19	24	25	17	5

B. Extractable Calcium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 700	700-1400	1400-2800	> 2800
		parts per million			
Coarse	308	64	25	9	2
Medium	2702	43	41	14	2
		< 1400	1400-2800	2800-4000	> 4000
		parts per million			
Fine	995	29	46	17	8
Average*		41	41	14	4

C. Extractable Magnesium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 70	70-140	140-280	> 280
		parts per million			
Coarse	308	8	35	43	14
Medium	2702	3	24	51	22
		< 140	140-280	280-450	> 450
		parts per million			
Fine	995	2	10	28	60
Average*		3	21	45	31

D. Extractable Potassium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 110	110-165	165-220	> 220
		parts per million			
Coarse	308	33	37	18	12
Medium	2702	26	38	23	13
		< 160	160-240	240-320	> 320
		parts per million			
Fine	995	33	31	20	16
Average*		28	36	22	14

E. Extractable Phosphorus

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 60	60-120	120-180	> 180
		parts per million			
Coarse	308	55	31	7	7
Medium	2702	32	44	17	7
		< 80	80-160	160-240	> 240
		parts per million			
Fine	995	64	27	7	2
Average*		41	39	14	6

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 7.-Summary of soil test results of soil samples from the Mississippi Terrace Area. 1964-1967.

A. Soil Reaction (pH)

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
		<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Medium	7158	9	30	28	21	10	2

B. Extractable Calcium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 500	500-1000	1000-2000	> 2000
		parts per million			
Medium	7158	30	49	18	3

C. Extractable Magnesium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 50	50-100	100-200	> 200
		parts per million			
Medium	7158	1	10	49	40

D. Extractable Potassium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 100	100-150	150-200	> 200
		parts per million			
Medium	7158	37	34	18	11

E. Extractable Phosphorus

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 55	55-110	110-165	> 165
		parts per million			
Medium	7158	64	25	7	4

Table 8.-Summary of soil test results of soil samples from the Loessial Hill Area. 1964-1967.

A. Soil Reaction (pH)

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
		< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Coarse	1136	16	31	27	19	7	0
Medium	402	9	31	26	22	11	1
Average*		14	31	27	20	8	0

B. Extractable Calcium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 500	500-1000	1000-2000	> 2000
		parts per million			
Coarse	1136	57	31	10	2
Medium	402	44	41	13	2
Average*		53	34	11	2

C. Extractable Magnesium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 50	50-100	100-200	> 200
		parts per million			
Coarse	1136	8	33	37	22
Medium	402	2	23	48	27
Average*		6	31	40	23

D. Extractable Potassium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 100	100-150	150-200	> 200
		parts per million			
Coarse	1136	51	30	12	7
Medium	402	47	32	14	7
Average*		50	30	13	7

E. Extractable Phosphorus

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 55	55-110	110-165	> 165
		parts per million			
Coarse	1136	59	22	7	12
Medium	402	80	14	2	4
Average*		64	20	6	10

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 9.-Summary of soil test results of soil samples from the Coastal Prairie Area. 1964-1967.

A. Soil Reaction (pH)

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
		<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coarse	80	6	28	34	14	5	13
Medium	2031	9	31	27	20	10	3
Fine	465	6	23	30	20	15	6
Average*		8	29	28	20	11	4

B. Extractable Calcium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 600	600-1200	1200-2400	> 2400
		parts per million			
Coarse	80	53	24	10	13
Medium	2031	37	47	14	2
Fine	465	8	35	41	16
Average*		32	44	19	5

C. Extractable Magnesium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 60	60-120	120-240	> 240
		parts per million			
Coarse	80	5	39	31	25
Medium	2031	2	17	43	38
Fine	465	1	1	11	87
Average*		2	15	37	46

D. Extractable Potassium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 100	100-150	150-200	> 200
		parts per million			
Coarse	80	69	16	6	9
Medium	2031	68	22	6	4
Fine	465	57	26	8	9
Average*		66	23	6	5

E. Extractable Phosphorus

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 35	35-70	70-105	> 105
		parts per million			
Coarse	80	65	15	6	14
Medium	2031	78	14	4	4
Fine	465	78	12	5	5
Average*		78	14	4	4

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 10.-Summary of soil test results of soil samples from the Flatwoods Area. 1964-1967.

A. Soil Reaction (pH)

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
		<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coarse	4268	12	25	27	26	9	1
Medium	535	17	30	25	20	7	1
Average*		13	26	27	25	8	1

B. Extractable Calcium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		<400	400-800	800-1600	>1600
		parts per million			
Coarse	4268	32	36	29	3
Medium	535	34	33	29	4
Average*		32	36	29	3

C. Extractable Magnesium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		<40	40-80	80-160	>160
		parts per million			
Coarse	4268	3	18	41	38
Medium	535	3	16	45	36
Average*		3	18	41	38

D. Extractable Potassium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		<80	80-120	120-160	>160
		parts per million			
Coarse	4268	38	28	18	16
Medium	535	51	24	15	10
Average*		39	28	18	15

E. Extractable Phosphorus

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		<35	35-70	70-105	>105
		parts per million			
Coarse	4268	36	20	9	35
Medium	535	46	12	9	33
Average*		37	19	9	35

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 11.-Summary of soil test results of soil samples from the Coastal Plain Area. 1964-1967.

A. Soil Reaction (pH)

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
		<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coarse	4450	5	19	28	28	16	4
Medium	153	11	36	22	18	10	3
Average*		5	20	28	28	15	4

B. Extractable Calcium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		< 300	300-500	500-1000	>1000
		parts per million			
Coarse	4450	27	27	32	14
Medium	153	15	27	30	28
Average*		27	27	32	14

C. Extractable Magnesium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		<30	30-50	50-100	>100
		parts per million			
Coarse	4450	5	9	35	51
Medium	153	1	2	28	69
Average*		5	9	35	51

D. Extractable Potassium

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		<80	80-120	120-160	>160
		parts per million			
Coarse	4450	40	30	17	13
Medium	153	39	27	18	16
Average*		40	30	17	13

E. Extractable Phosphorus

Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
		<40	40-80	80-120	>120
		parts per million			
Coarse	4450	62	21	8	9
Medium	153	75	12	7	6
Average*		62	21	8	9

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 12.-Summary of soil test results of soil samples from Acadia Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Prairie	Medium	674	7	27	24	25	13	4
	Fine	141	6	16	30	27	15	6
	Average*		7	25	25	26	13	4
Miss. Terrace	Medium	234	10	30	30	22	8	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 600	600-1200	1200-2400	> 2400
			parts per million			
Coastal Prairie	Medium	674	28	57	13	2
	Fine	141	11	50	33	6
	Average*		25	55	17	3
			< 500	500-1000	1000-2000	> 2000
			parts per million			
Miss. Terrace	Medium	234	25	55	19	1

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-240	> 240
			parts per million			
Coastal Prairie	Medium	674	2	10	39	49
	Fine	141	0	1	11	88
	Average*		2	8	34	56
			< 50	50-100	100-200	> 200
			parts per million			
Miss. Terrace	Medium	234	0	6	48	46

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 100	100-150	150-200	> 200
			parts per million			
Coastal Prairie	Medium	674	68	23	5	4
	Fine	141	71	24	3	2
	Average*		68	23	5	4
			< 100	100-150	150-200	> 200
			parts per million			
Miss. Terrace	Medium	234	58	25	11	6

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 35	35-70	70-105	> 105
			parts per million			
Coastal Prairie	Medium	674	84	11	3	2
	Fine	141	89	5	4	2
	Average*		85	10	3	2
			< 55	55-110	110-165	> 165
			parts per million			
Miss. Terrace	Medium	234	81	13	3	3

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 13.-Summary of soil test results of soil samples from Allen Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Flatwoods	Coarse	131	6	41	37	10	6	0
	Medium	100	13	41	15	24	6	1
	Average*		9	41	27	16	6	1
Coastal Prairie	Medium	70	20	38	23	14	5	0
Coastal Plain	Coarse	37	3	23	37	23	14	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 400	400-800	800-1600	>1600
			parts per million			
Flatwoods	Coarse	131	74	21	3	2
	Medium	100	45	32	19	4
	Average*		61	26	10	3
			< 600	600-1200	1200-2400	>2400
			parts per million			
Coastal Prairie	Medium	70	70	23	5	2
			< 300	300-500	500-1000	>1000
			parts per million			
Coastal Plain	Coarse	37	31	34	26	9

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 40	40-80	80-160	>160
			parts per million			
Flatwoods	Coarse	131	3	42	44	11
	Medium	100	4	21	55	20
	Average*		3	33	49	15
			<60	60-120	120-240	>240
			parts per million			
Coastal Prairie	Medium	70	6	49	33	12
			< 30	30-50	50-100	>100
			parts per million			
Coastal Plain	Coarse	37	14	14	46	26

(Continued)

Table 13.-(Continued) Summary of soil test results of soil samples from Allen Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 80	80-120	120-160	> 160
			parts per million			
Flatwoods	Coarse	131	63	29	6	2
	Medium	100	64	27	6	3
	Average*		64	28	6	2
			< 100	100-150	150-200	> 200
			parts per million			
Coastal Prairie	Medium	70	81	11	3	5
			< 80	80-120	120-160	> 160
			parts per million			
Coastal Plain	Coarse	37	57	31	9	3

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 35	35-70	70-105	> 105
			parts per million			
Flatwoods	Coarse	131	67	21	7	5
	Medium	100	67	12	6	15
	Average*		67	17	6	10
			< 35	35-70	70-105	> 105
			parts per million			
Coastal Prairie	Medium	70	83	6	2	9
			< 40	40-80	80-120	> 120
			parts per million			
Coastal Plain	Coarse	37	63	31	0	6

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 14.-Summary of soil test results of soil samples from Ascension Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. R. Alluvial	Medium	113	0	13	21	31	22	13
	Fine	215	0	7	33	38	15	7
	Average*		0	9	29	36	17	9
Miss. Terrace	Medium	104	4	33	39	19	4	1

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	>2800
			parts per million			
Miss. R. Alluvial	Medium	113	4	19	62	15
			< 1400	1400-2800	2800-4000	>4000
			parts per million			
	Fine	215	2	43	46	9
	Average*		3	34	52	11
			< 500	500-1000	1000-2000	> 2000
			parts per million			
Miss. Terrace	Medium	104	22	41	31	6

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	>280
			parts per million			
Miss. R. Alluvial	Medium	113	0	3	13	84
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	215	0	2	11	87
	Average*		0	2	12	86
			< 50	50-100	100-200	> 200
			parts per million			
Miss. Terrace	Medium	104	0	16	43	41

(Continued)

Table 14.-(Continued) Summary of soil test results of soil samples from Ascension Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			parts per million			
Miss. R. Alluvial	Medium	113	35	35	21	9
			<160	160-240	240-320	>320
			parts per million			
	Fine	215	29	34	27	10
	Average*		31	34	25	10
			<100	100-150	150-200	>200
			parts per million			
Miss. Terrace	Medium	104	73	20	4	3

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			parts per million			
Miss. R. Alluvial	Medium	113	17	13	13	57
			<80	80-160	160-240	>240
			parts per million			
	Fine	215	19	18	35	28
	Average*		18	17	27	38
			<55	55-110	110-165	>165
			parts per million			
Miss. Terrace	Medium	104	73	13	7	7

* Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 15.-Summary of soil test results of soil samples from Assumption Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Medium	125	0	2	17	30	25	26
	Fine	590	0	1	23	50	20	6
	Average*		0	1	22	46	21	10

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 700	700-1400	1400-2800	> 2800
			--------------------parts per million------------------			
Miss. River Alluvial	Medium	125	0	3	86	11
			< 1400	1400-2800	2800-4000	> 4000
			--------------------parts per million------------------			
	Fine	590	0	39	47	14
	Average*		0	33	53	14

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 70	70-140	140-280	> 280
			--------------------parts per million------------------			
Miss. River Alluvial	Medium	125	0	0	2	98
			< 140	140-280	280-450	> 450
			--------------------parts per million------------------			
	Fine	590	0	0	3	97
	Average*		0	0	3	97

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 110	110-165	165-220	> 220
			--------------------parts per million------------------			
Miss. River Alluvial	Medium	125	27	52	13	8
			< 160	160-240	240-320	> 320
			--------------------parts per million------------------			
	Fine	590	32	41	21	6
	Average*		31	43	20	6

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 60	60-120	120-180	> 180
			--------------------parts per million------------------			
Miss. River Alluvial	Medium	125	1	3	8	88
			< 80	80-160	160-240	> 240
			--------------------parts per million------------------			
	Fine	590	1	16	53	30
	Average*		1	14	45	40

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 16.-Summary of soil test results of soil samples from Avoyelles Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Red River Alluvial	Coarse	10	0	10	10	10	20	50
	Medium	382	1	4	8	11	10	66
	Fine	293	0	1	6	17	18	58
	Average*		1	3	7	14	14	61
Miss. Terrace	Medium	512	13	36	28	15	6	2
Miss. R. Alluvial	Medium	8	0	28	29	14	0	29
	Fine	18	6	22	33	22	6	11
	Average*		4	24	32	20	4	16

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	> 2800
			------------------parts per million----------------			
Red R. Alluvial	Coarse	10	30	10	40	20
	Medium	382	13	20	30	37
			< 1400	1400-2800	2800-4000	> 4000
			------------------parts per million----------------			
	Fine	293	2	12	23	63
	Average*		9	16	27	48
			< 500	500-1000	1000-2000	> 2000
			------------------parts per million----------------			
Miss. Terrace	Medium	512	38	46	13	3
			< 700	700-1400	1400-2800	> 2800
			------------------parts per million----------------			
Miss. R. Alluvial	Medium	8	28	29	29	14
			< 1400	1400-2800	2800-4000	> 4000
			------------------parts per million----------------			
	Fine	18	11	44	45	0
	Average*		15	39	42	4

(Continued)

Table 16.-(Continued) Summary of soil test results of soil samples from Avoyelles Parish. 1964-1967.

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<70	70-140	140-280	>280
			parts per million			
Red R. Alluvial	Coarse	10	0	0	30	70
	Medium	382	0	1	16	83
			<140	140-280	280-450	>450
			parts per million			
	Fine	293	0	1	3	96
	Average*		0	1	11	88
			<50	50-100	100-200	>200
			parts per million			
Miss. Terrace	Medium	512	0	13	55	32
			<70	70-140	140-280	>280
			parts per million			
Miss. River Alluvial	Medium	8	0	0	29	71
			<140	140-280	280-450	>450
			parts per million			
	Fine	18	6	0	11	83
	Average*		4	0	15	81

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			parts per million			
Red R. Alluvial	Coarse	10	20	40	30	10
	Medium	382	25	38	24	13
			<160	160-240	240-320	>320
			parts per million			
	Fine	293	13	26	30	31
	Average*		20	32	27	21
			<100	100-150	150-200	>200
			parts per million			
Miss. Terrace	Medium	512	32	37	22	9
			<110	110-165	165-220	>220
			parts per million			
Miss. River Alluvial	Medium	8	28	29	29	14
			<160	160-240	240-320	>320
			parts per million			
	Fine	18	28	28	22	22
	Average*		27	27	27	19

(Continued)

Table 16.-(Continued) Summary of soil test results of soil samples from Avoyelles Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			parts per million			
Red R. Alluvial	Coarse	10	10	40	30	20
	Medium	382	5	21	32	42
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	293	7	33	48	12
	Average*		6	26	39	29
			< 55	55-110	110-165	> 165
			parts per million			
Miss. Terrace	Medium	512	78	14	4	4
			< 60	60-120	120-180	> 180
			parts per million			
Miss. R. Alluvial	Medium	8	14	43	0	43
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	18	66	6	17	11
	Average*		51	16	13	20

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 17.-Summary of soil test results of soil samples from Beauregard Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	140	6	40	26	19	8	1
	Medium	16	13	37	37	13	0	0
	Average*		6	40	27	19	7	1
Flatwoods	Coarse	118	15	31	28	20	6	0
	Medium	59	5	41	26	25	3	0
	Average*		12	35	27	21	5	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <300	300-500	500-1000	>1000
			---parts	per	million---	
Coastal Plain	Coarse	140	39	23	30	8
	Medium	16	37	19	38	6
	Average*		39	22	31	8
			<400	400-800	800-1600	>1600
			---parts	per	million---	
Flatwoods	Coarse	118	50	32	16	2
	Medium	59	50	31	17	2
	Average*		50	32	16	2

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <30	30-50	50-100	>100
			---parts	per	million---	
Coastal Plain	Coarse	140	2	10	49	39
	Medium	16	0	6	31	63
	Average*		2	10	46	42
			<40	40-80	80-160	>160
			---parts	per	million---	
Flatwoods	Coarse	118	8	32	31	29
	Medium	59	5	37	46	12
	Average*		7	34	36	23

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <80	80-120	120-160	>160
			---parts	per	million---	
Coastal Plain	Coarse	140	68	20	6	6
	Medium	16	69	25	6	0
	Average*		68	21	6	5
			<80	80-120	120-160	>160
			---parts	per	million---	
Flatwoods	Coarse	118	63	22	10	5
	Medium	59	76	17	5	2
	Average*		68	20	8	4

(Continued)

Table 17.- (Continued) Summary of soil test results of soil samples from Beauregard Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <40	40-80	80-120	>120
			parts per million			
Coastal Plain	Coarse	140	59	18	14	9
	Medium	16	87	13	0	0
	Average*		62	17	13	8
			<35	35-70	70-105	>105
			parts per million			
Flatwoods	Coarse	118	55	19	10	16
	Medium	59	69	14	12	5
	Average*		60	17	11	12

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 18.-Summary of soil test results of soil samples from Bienville Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	16	13	0	68	13	6	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <300	300-500	500-1000	>1000
			parts per million			
Coastal Plain	Coarse	16	56	31	13	0

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <30	30-50	50-100	>100
			parts per million			
Coastal Plain	Coarse	16	19	13	62	6

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <80	80-120	120-160	>160
			parts per million			
Coastal Plain	Coarse	16	25	50	19	6

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <40	40-80	80-120	>120
			parts per million			
Coastal Plain	Coarse	16	44	25	6	25

Table 19.-Summary of soil test results of soil samples from Bossier Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Red R. Alluvial	Coarse	6	0	0	0	17	0	83
	Medium	97	0	4	7	9	7	73
	Fine	154	0	1	2	7	20	70
	Average*		0	2	4	8	15	71
Coastal Plain	Coarse	201	3	14	33	29	16	5
	Medium	21	24	24	24	24	4	0
	Average*		5	15	32	28	15	5

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 700	700-1400	1400-2800	> 2800
			------parts per million------			
Red R. Alluvial	Coarse	6	0	33	33	34
	Medium	97	7	22	17	54
			< 1400	1400-2800	2800-4000	> 4000
			------parts per million------			
	Fine	154	2	16	26	56
	Average*		4	19	23	54
			< 300	300-500	500-1000	> 1000
			------parts per million------			
Coastal Plain	Coarse	201	25	26	36	13
	Medium	21	34	33	29	4
	Average*		26	27	35	12

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 70	70-140	140-280	> 280
			------parts per million------			
Red R. Alluvial	Coarse	6	0	0	0	100
	Medium	97	3	2	8	87
			< 140	140-280	280-450	> 450
			------parts per million------			
	Fine	154	0	1	3	96
	Average*		1	1	5	93
			< 30	30-50	50-100	> 100
			------parts per million------			
Coastal Plain	Coarse	201	4	9	35	52
	Medium	21	0	0	52	48
	Average*		4	8	36	52

(Continued)

Table 19.-(Continued) Summary of soil test results of soil samples from Bossier Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			parts per million			
Red R. Alluvial	Coarse	6	0	50	33	17
	Medium	97	11	34	31	24
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	154	10	36	40	14
	Average*		10	35	37	18
			< 80	80-120	120-160	> 160
			parts per million			
Coastal Plain	Coarse	201	33	23	28	16
	Medium	21	28	24	19	29
	Average*		33	23	27	17

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			parts per million			
Red R. Alluvial	Coarse	6	0	17	83	0
	Medium	97	14	15	45	26
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	154	8	26	44	22
	Average*		10	22	45	23
			< 40	40-80	80-120	> 120
			parts per million			
Coastal Plain	Coarse	201	75	16	5	4
	Medium	21	75	10	10	5
	Average*		75	15	6	4

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 20.-Summary of soil test results of soil samples from Caddo Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Red R. Alluvial	Coarse	6	0	0	17	17	0	66
	Medium	333	0	0	5	6	4	85
	Fine	434	0	0	5	12	24	59
	Average*		0	0	5	9	15	71
Coastal Plain	Coarse	430	4	13	23	30	21	9
	Medium	32	0	25	29	17	29	0
	Average*		4	14	23	29	21	9

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Red R. Alluvial	Coarse	6	17	17	49	17
	Medium	333	2	11	20	67
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	434	8	30	18	44
	Average*		6	22	19	53
			< 300	300-500	500-1000	> 1000
			parts per million			
Coastal Plain	Coarse	430	25	27	31	17
	Medium	32	0	21	25	54
	Average*		23	27	31	19

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			parts per million			
Red R. Alluvial	Coarse	6	0	17	17	66
	Medium	333	0	1	2	97
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	434	1	2	7	90
	Average*		1	2	5	92
			< 30	30-50	50-100	> 100
			parts per million			
Coastal Plain	Coarse	430	6	10	42	42
	Medium	32	0	0	25	75
	Average*		6	9	41	44

(Continued)

Table 20.-(Continued) Summary of soil test results of soil samples from Caddo Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			parts per million			
Red R. Alluvial	Coarse	6	17	33	17	33
	Medium	333	14	39	27	20
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	434	22	37	25	16
	Average*		18	38	26	18
			< 80	80-120	120-160	> 160
			parts per million			
Coastal Plain	Coarse	430	38	29	18	15
	Medium	32	13	46	21	20
	Average*		37	30	18	15

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			parts per million			
Red R. Alluvial	Coarse	6	17	17	33	33
	Medium	333	1	13	52	34
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	434	10	24	42	24
	Average*		6	19	47	28
			< 40	40-80	80-120	> 120
			parts per million			
Coastal Plain	Coarse	430	71	18	5	6
	Medium	32	63	21	4	12
	Average*		70	18	5	7

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 21.-Summary of soil test results of soil samples from Calcasieu Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Coastal Prairie	Coarse	37	11	22	28	17	3	19
	Medium	252	10	29	24	23	12	2
	Fine	28	4	15	25	22	30	4
	Average*		9	28	24	23	12	4
Flatwoods	Coarse	30	3	33	20	28	3	13
	Medium	9	44	23	22	11	0	0
	Average*		12	31	21	23	3	10

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 600	600-1200	1200-2400	> 2400
			parts per million			
Coastal Prairie	Coarse	37	53	22	11	14
	Medium	252	49	31	19	1
	Fine	28	4	22	41	33
	Average*		46	29	20	5
			< 400	400-800	800-1600	> 1600
			parts per million			
Flatwoods	Coarse	30	40	30	23	7
	Medium	9	34	33	22	11
	Average*		38	31	23	8

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-240	> 240
			parts per million			
Coastal Prairie	Coarse	37	6	47	28	19
	Medium	252	8	26	38	28
	Fine	28	0	0	7	93
	Average*		7	26	34	33
			< 40	40-80	80-160	> 160
			parts per million			
Flatwoods	Coarse	30	7	13	47	33
	Medium	9	0	22	56	22
	Average*		5	15	49	31

(Continued)

Table 21.-(Continued) Summary of soil test results of soil samples from Calcasieu Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 100	100-150	150-200	> 200
			--------parts	per	million--------	
Coastal Prairie	Coarse	37	78	14	0	8
	Medium	252	85	9	3	3
	Fine	28	67	7	15	11
	Average*		83	9	4	4
			< 80	80-120	120-160	>160
			--------parts	per	million--------	
Flatwoods	Coarse	30	57	23	3	17
	Medium	9	67	22	0	11
	Average*		59	23	3	15

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 35	35-70	70-105	> 105
			--------parts	per	million--------	
Coastal Prairie	Coarse	37	69	8	6	17
	Medium	252	79	10	3	8
	Fine	28	70	4	4	22
	Average*		78	9	3	10
Flatwoods	Coarse	30	84	4	4	8
	Medium	9	89	0	0	11
	Average*		85	3	3	9

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 22.-Summary of soil test results of soil samples from Caldwell Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Ouachita River Alluvial	Coarse	35	21	32	26	6	15	0
	Medium	285	8	22	26	28	15	1
	Fine	84	15	27	23	14	19	2
	Average*		11	24	25	23	16	1
Coastal Plain	Coarse	56	12	40	23	19	4	2

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Ouachita River Alluvial	Coarse	35	68	23	6	3
	Medium	285	40	46	13	1
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	84	21	54	15	10
	Average*		39	46	13	2
			< 300	300-500	500-1000	>1000
			parts per million			
Coastal Plain	Coarse	56	27	48	17	8

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			parts per million			
Ouachita River Alluvial	Coarse	35	18	29	38	15
	Medium	285	2	27	49	22
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	84	1	5	25	69
	Average*		3	23	43	31
			< 30	30-50	50-100	> 100
			parts per million			
Coastal Plain	Coarse	56	2	8	53	37

(Continued)

Table 22.-(Continued) Summary of soil test results of soil samples from Caldwell Parish. 1964-1967

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			parts per million			
Ouachita River Alluvial	Coarse	35	58	18	21	3
	Medium	285	39	39	15	7
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	84	31	25	24	20
	Average*		39	35	17	9
			< 80	80-120	120-160	> 160
			parts per million			
Coastal Plain	Coarse	56	35	37	15	13

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			parts per million			
Ouachita River Alluvial	Coarse	35	56	41	3	0
	Medium	285	40	41	15	4
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	84	62	28	7	3
	Average*		46	39	12	3
			< 40	40-80	80-120	> 120
			parts per million			
Coastal Plain	Coarse	56	79	15	0	6

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 23.-Summary of soil test results of soil samples from Cameron Parish. 1964-1967.

A. Soil Reaction (pH)

			Percentage of samples testing in the following ranges:					
Soil Area	Soil Texture	No. of Samples	< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Coastal Prairie	Coarse	14	7	29	50	0	14	0
	Medium	52	10	37	25	12	6	10
	Fine	17	6	12	18	12	34	18
	Average*		8	31	28	10	13	10

B. Extractable Calcium

			Percentage of samples testing in the following ranges:			
Soil Area	Soil Texture	No. of Samples	< 600	600-1200	1200-2400	> 2400
			parts per million			
Coastal Prairie	Coarse	14	50	43	7	0
	Medium	52	42	38	12	8
	Fine	17	6	12	47	35
	Average *		36	34	18	12

C. Extractable Magnesium

			Percentage of samples testing in the following ranges:			
Soil Area	Soil Texture	No. of Samples	< 60	60-120	120-240	> 240
			parts per million			
Coastal Prairie	Coarse	14	0	43	36	21
	Medium	52	0	19	41	40
	Fine	17	0	0	6	94
	Average *		0	19	33	48

D. Extractable Potassium

			Percentage of samples testing in the following ranges:			
Soil Area	Soil Texture	No. of Samples	< 100	100-150	150-200	> 200
			parts per million			
Coastal Prairie	Coarse	14	72	7	21	0
	Medium	52	59	25	10	6
	Fine	17	35	29	12	24
	Average *		56	24	12	8

E. Extractable Phosphorus

			Percentage of samples testing in the following ranges:			
Soil Area	Soil Texture	No. of Samples	< 35	35-70	70-105	> 105
			parts per million			
Coastal Prairie	Coarse	14	86	7	0	7
	Medium	52	74	12	8	6
	Fine	17	53	24	17	6
	Average *		72	14	8	6

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 24.-Summary of soil test results of soil samples from Catahoula Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Coarse	3	0	33	33	0	34	0
	Medium	55	9	22	22	18	18	11
	Fine	250	21	40	23	12	2	2
	Average*		19	36	23	13	5	4
Ouachita River Alluvial	Coarse	10	0	72	14	0	14	0
	Medium	74	13	16	29	14	12	16
	Fine	114	15	35	24	8	4	14
	Average*		13	30	25	10	8	14
Miss. Terrace	Medium	86	6	31	45	15	3	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 700	700-1400	1400-2800	>2800
			------------------parts per million------------------			
Miss. River Alluvial	Coarse	3	33	0	33	34
	Medium	55	11	24	54	11
			<1400	1400-2800	2800-4000	>4000
			------------------parts per million------------------			
	Fine	250	5	39	42	14
	Average*		6	36	44	14
			< 700	700-1400	1400-2800	>2800
			------------------parts per million------------------			
Ouachita River Alluvial	Coarse	10	72	14	14	0
	Medium	74	27	40	21	12
			< 1400	1400-2800	2800-4000	> 4000
			------------------parts per million------------------			
	Fine	114	16	36	34	14
	Average*		23	36	29	12
			< 500	500-1000	1000-2000	> 2000
			------------------parts per million------------------			
Miss. Terrace	Medium	86	28	63	9	0

(Continued)

Table 24.- (Continued) Summary of soil test results of soil samples from Catahoula Parish. 1964-1967.

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			parts per million			
Miss. River Alluvial	Coarse	3	33	0	33	34
	Medium	55	4	5	27	64
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	250	1	2	7	90
	Average*		2	3	11	84
			< 70	70-140	140-280	> 280
			parts per million			
Ouachita River Alluvial	Coarse	10	29	29	42	0
	Medium	74	0	7	42	51
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	114	3	4	18	75
	Average*		3	7	28	62
			< 50	50-100	100-200	> 200
			parts per million			
Miss. Terrace	Medium	83	0	14	67	19

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			parts per million			
Miss. River Alluvial	Coarse	3	33	0	33	34
	Medium	55	35	47	9	9
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	250	25	35	24	16
	Average*		27	37	21	15
			< 110	110-165	165-220	> 220
			parts per million			
Ouachita River Alluvial	Coarse	10	100	0	0	0
	Medium	74	43	29	19	9
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	114	23	50	22	5
	Average*		34	39	20	7
			< 100	100-150	150-200	> 200
			parts per million			
Miss. Terrace	Medium	86	39	44	13	4

(Continued)

Table 24.-(Continued) Summary of soil test results of soil samples from Catahoula Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			---------------------	parts per million	---------------------	
Miss. River Alluvial	Coarse	3	33	0	33	34
	Medium	55	38	24	20	18
			< 80	80-160	160-240	> 240
			---------------------	parts per million	---------------------	
	Fine	250	68	26	4	2
	Average*		63	25	7	5
			< 60	60-120	120-180	> 180
			---------------------	parts per million	---------------------	
Ouachita River Alluvial	Coarse	10	86	0	14	0
	Medium	74	63	30	4	3
			< 80	80-160	160-240	> 240
			---------------------	parts per million	---------------------	
	Fine	114	70	22	7	1
	Average*		68	24	6	2
			< 55	55-110	110-165	> 165
			---------------------	parts per million	---------------------	
Miss. Terrace	Medium	86	25	55	11	9

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 25.-Summary of soil test results of soil samples from Claiborne Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	12	0	0	25	50	17	8

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<300	300-500	500-1000	>1000
			-------------------parts per million-------------------			
Coastal Plain	Coarse	12	42	25	33	0

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<30	30-50	50-100	>100
			-------------------parts per million-------------------			
Coastal Plain	Coarse	12	17	42	41	0

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<80	80-120	120-160	>160
			-------------------parts per million-------------------			
Coastal Plain	Coarse	12	8	59	8	25

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<40	40-80	80-120	>120
			-------------------parts per million-------------------			
Coastal Plain	Coarse	12	50	17	33	0

Table 26.-Summary of soil test results of soil samples from Concordia Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Coarse	3	33	34	33	0	0	0
	Medium	134	0	7	30	42	11	10
	Fine	185	1	17	42	31	6	3
	Average*		1	13	37	35	8	6
Red R. Alluvial	Fine	9	0	0	0	33	0	67

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	> 2800
			------------------parts per million-----------------			
Miss. River Alluvial	Coarse	3	0	100	0	0
	Medium	134	0	26	69	5
			< 1400	1400-2800	2800-4000	> 4000
			------------------parts per million-----------------			
	Fine	185	0	46	39	15
	Average*		0	38	51	11
Red R. Alluvial	Fine	9	0	0	0	100

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			------------------parts per million-----------------			
Miss. River Alluvial	Coarse	3	0	0	100	0
	Medium	134	0	1	38	61
			< 140	140-280	280-450	> 450
			------------------parts per million-----------------			
	Fine	185	1	3	20	76
	Average*		1	2	28	69
Red R. Alluvial	Fine	9	0	0	0	100

(Continued)

Table 26.-(Continued) Summary of soil test results of soil samples from Concordia Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			parts per million			
Miss. River Alluvial	Coarse	3	0	33	67	0
	Medium	134	5	25	40	30
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	185	7	26	26	41
	Average*		6	26	32	36
Red R. Alluvial	Fine	9	0	0	0	100

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			parts per million			
Miss. River Alluvial	Coarse	3	0	33	67	0
	Medium	134	5	23	27	45
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	185	16	53	22	9
	Average*		11	40	25	24
Red R. Alluvial	Fine	9	0	0	67	33

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 27.-Summary of soil test results of soil samples from DeSoto Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	355	1	8	23	32	29	7
	Medium	9	0	13	0	50	13	24
	Average*		1	8	23	32	29	7
Red R. Alluvial	Medium	8	0	0	33	50	17	0
	Fine	23	0	0	9	52	17	22
	Average*		0	0	15	52	17	16

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<300	300-500	500-1000	>1000
			parts per million			
Coastal Plain	Coarse	355	20	23	38	19
	Medium	9	0	0	38	62
	Average*		20	23	38	19
			<700	700-1400	1400-2800	>2800
			parts per million			
Red R. Alluvial	Medium	8	0	67	33	0
			<1400	1400-2800	2800-4000	>4000
			parts per million			
	Fine	23	17	66	13	4
	Average*		13	65	19	3

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<30	30-50	50-100	>100
			parts per million			
Coastal Plain	Coarse	355	3	9	33	55
	Medium	9	0	0	0	100
	Average*		3	9	32	56
			<70	70-140	140-280	>280
			parts per million			
Red R. Alluvial	Medium	8	0	0	17	83
			<140	140-280	280-450	>450
			parts per million			
	Fine	23	0	0	17	83
	Average*		0	0	16	84

(Continued)

Table 27.-(Continued) Summary of soil test results of soil samples from DeSoto Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 80	80-120	120-160	> 160
			parts per million			
Coastal Plain	Coarse	355	28	34	21	17
	Medium	9	24	13	25	38
	Average*		28	34	21	17
			< 110	110-165	165-220	> 220
			parts per million			
Red R. Alluvial	Medium	8	33	50	17	0
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	23	30	48	22	0
	Average*		32	48	20	0

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 40	40-80	80-120	> 120
			parts per million			
Coastal Plain	Coarse	355	53	25	12	10
	Medium	9	37	13	50	0
	Average*		52	25	13	10
			< 60	60-120	120-180	> 180
			parts per million			
Red R. Alluvial	Medium	8	0	100	0	0
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	23	35	61	4	0
	Average*		26	71	3	0

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 28.-Summary of soil test results of soil samples from East Baton Rouge Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. Terrace	Medium	512	7	24	24	24	17	4
Miss. River Alluvial	Medium	4	0	34	0	33	0	33
	Fine	60	7	0	23	44	23	3
	Average*		6	3	22	42	22	5

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 500	500-1000	1000-2000	> 2000
			parts per million			
Miss. Terrace	Medium	512	28	51	17	4
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Miss. River Alluvial	Medium	4	33	0	34	33
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	60	3	24	65	8
	Average*		5	22	64	9

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 50	50-100	100-200	> 200
			parts per million			
Miss. Terrace	Medium	512	1	18	45	36
			< 70	70-140	140-280	> 280
			parts per million			
Miss. River Alluvial	Medium	4	33	0	0	67
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	60	2	3	15	80
	Average*		3	3	14	80

(Continued)

Table 28.-(Continued) Summary of soil test results of soil samples from East Baton Rouge Parish. 1964-1967.

D. Extractable Potassium

			Percentage of samples testing in the following ranges:			
Soil Area	Soil Texture	No. of Samples	<100	100-150	150-200	>200
			parts per million			
Miss. Terrace	Medium	512	73	18	4	5
			<110	110-165	165-220	>220
			parts per million			
Miss. River Alluvial	Medium	4	33	67	0	0
			<160	160-240	240-320	>320
			parts per million			
	Fine	60	15	32	36	17
	Average*		16	34	34	16

E. Extractable Phosphorus

			Percentage of samples testing in the following ranges:			
Soil Area	Soil Texture	No. of Samples	<55	55-110	110-165	>165
			parts per million			
Miss. Terrace	Medium	512	83	11	2	4
			<60	60-120	120-180	>180
			parts per million			
Miss. River Alluvial	Medium	4	33	0	0	67
			<80	80-160	160-240	>240
			parts per million			
	Fine	60	8	47	37	8
	Average*		9	44	34	13

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 29.-Summary of soil test results of soil samples from East Carroll Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Coarse	8	0	13	0	25	0	62
	Medium	67	0	2	0	30	28	40
	Fine	185	0	2	16	40	20	22
	Average*		0	2	12	36	22	28

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 700	700-1400	1400-2800	> 2800
			parts per million			
Miss. River Alluvial	Coarse	8	12	25	38	25
	Medium	67	0	8	69	23
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	185	0	20	46	34
	Average*		1	17	51	31

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 70	70-140	140-280	>280
			parts per million			
Miss. River Alluvial	Coarse	8	0	12	13	75
	Medium	67	0	0	13	87
			< 140	140-280	280-450	>450
			parts per million			
	Fine	185	0	1	4	95
	Average*		0	1	7	92

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <110	110-165	165-220	>220
			parts per million			
Miss. River Alluvial	Coarse	8	0	38	25	37
	Medium	67	7	15	24	54
			<160	160-240	240-320	>320
			parts per million			
	Fine	185	3	18	37	42
	Average*		4	18	33	45

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 60	60-120	120-180	>180
			parts per million			
Miss. River Alluvial	Coarse	8	0	13	0	87
	Medium	67	2	3	8	87
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	185	2	27	36	35
	Average*		2	20	28	50

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 30.-Summary of soil test results of soil samples from East Feliciana Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Loessial Hills	Coarse	110	5	17	34	25	17	2
	Medium	347	6	30	24	25	13	2
	Average*		6	27	26	25	14	2

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <500	500-1000	1000-2000	>2000
			--------parts per million--------			
Loessial Hills	Coarse	110	44	40	16	0
	Medium	347	39	45	14	2
	Average*		40	44	15	1

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <50	50-100	100-200	>200
			--------parts per million--------			
Loessial Hills	Coarse	110	0	25	53	22
	Medium	347	2	19	52	27
	Average*		2	21	52	25

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <100	100-150	150-200	>200
			--------parts per million--------			
Loessial Hills	Coarse	110	46	42	9	3
	Medium	347	47	35	12	6
	Average*		47	35	12	6

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <55	55-110	110-165	>165
			--------parts per million--------			
Loessial Hills	Coarse	110	84	13	3	0
	Medium	347	85	10	1	4
	Average*		85	11	1	3

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 31.-Summary of soil test results of soil samples from Evangeline Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. Terrace	Medium	478	10	29	30	21	7	3
Coastal Prairie	Medium	165	6	24	37	24	7	2
	Fine	8	25	0	38	12	25	0
	Average*		6	23	37	24	8	2
Flatwoods	Coarse	8	17	67	0	16	0	0
	Medium	12	17	33	25	17	8	0
	Average*		17	48	15	15	5	0
Red R. Alluvial	Medium	15	0	0	18	9	36	37
	Fine	7	0	0	0	14	43	43
	Average*		0	0	14	9	36	41

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 500	500-1000	1000-2000	> 2000
			---parts per million---			
Miss. Terrace	Medium	478	41	49	8	2
			< 600	600-1200	1200-2400	> 2400
			---parts per million---			
Coastal Prairie	Medium	165	41	52	6	1
	Fine	8	38	37	25	0
	Average*		41	51	7	1
			< 700	700-1400	1400-2800	> 2800
			---parts per million---			
Red R. Alluvial	Medium	15	18	37	27	18
			< 1400	1400-2800	2800-4000	> 4000
			---parts per million---			
	Fine	7	0	29	57	14
	Average*		10	36	36	18
			< 400	400-800	800-1600	>1600
			---parts per million---			
Flatwoods	Coarse	8	50	33	0	17
	Medium	12	67	33	0	0
	Average*		60	35	0	5

(Continued)

Table 31.- (Continued) Summary of soil test results of soil samples from Evangeline Parish. 1964-1967.

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 50	50-100	100-200	> 200
			parts per million			
Miss. Terrace	Medium	478	2	19	58	21
			< 60	60-120	120-240	> 240
			parts per million			
Coastal Prairie	Medium	165	0	26	50	24
	Fine	8	13	0	25	62
	Average*		1	24	49	26
			< 70	70-140	140-280	> 280
			parts per million			
Red River Alluvial	Medium	15	0	0	18	82
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	7	0	0	0	100
	Average*		0	0	14	86
			< 40	40-80	80-160	> 160
			parts per million			
Flatwoods	Coarse	8	0	33	50	17
	Medium	12	0	17	67	16
	Average*		0	25	60	15

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 100	100-150	150-200	> 200
			parts per million			
Miss. Terrace	Medium	478	51	33	11	5
			< 100	100-150	150-200	> 200
			parts per million			
Coastal Prairie	Medium	165	63	27	7	3
	Fine	8	75	25	0	0
	Average*		64	26	7	3
			< 110	110-165	165-220	> 220
			parts per million			
Red River Alluvial	Medium	15	27	55	18	0
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	7	14	43	14	29
	Average*		23	50	18	9
			< 80	80-120	120-160	> 160
			parts per million			
Flatwoods	Coarse	8	50	33	17	0
	Medium	12	42	50	8	0
	Average*		45	45	10	0

(Continued)

Table 31.-(Continued) Summary of soil test results of soil samples from Evangeline Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 55	55-110	110-165	> 165
			parts per million			
Miss. Terrace	Medium	478	79	17	2	2
			< 35	35-70	70-105	> 105
			parts per million			
Coastal Prairie	Medium	165	76	18	4	2
	Fine	8	88	12	0	0
	Average*		76	18	4	2
			< 60	60-120	120-180	> 180
			parts per million			
Red R. Alluvial	Medium	15	0	55	36	9
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	7	29	42	29	0
	Average*		9	54	32	5
			< 35	35-70	70-105	>105
			parts per million			
Flatwoods	Coarse	8	100	0	0	0
	Medium	12	42	33	17	8
	Average*		65	20	10	5

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 32.-Summary of soil test results of soil samples from Franklin Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Miss. Terrace	Medium	1561	7	28	26	24	13	2
Miss. River Alluvial	Medium	10	0	20	40	10	20	10
	Fine	97	1	18	29	38	10	4
	Average*		1	18	30	35	11	5
Ouachita River Alluvial	Coarse	18	0	17	32	28	17	6
	Medium	7	0	29	0	57	14	0
	Fine	29	10	21	17	42	7	3
	Average*		6	20	18	39	13	4

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 500	500-1000	1000-2000	> 2000
			parts per million			
Miss. Terrace	Medium	1561	24	57	16	3
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Miss. River Alluvial	Medium	10	0	30	40	30
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	97	2	34	43	21
	Average*		2	34	43	21
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Ouachita River Alluvial	Coarse	18	56	44	0	0
	Medium	7	0	29	71	0
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	29	17	66	10	7
	Average*		27	54	15	4

(Continued)

Table 32.- (Continued) Summary of soil test results of soil samples from Franklin Parish. 1964-1967.

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 50	50-100	100-200	> 200
			parts per million			
Miss. Terrace	Medium	1561	0	6	51	43
			< 70	70-140	140-280	> 280
			parts per million			
Miss. River Alluvial	Medium	10	0	0	30	70
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	97	0	1	38	61
	Average*		0	1	37	62
			< 70	70-140	140-280	> 280
			parts per million			
Ouachita River Alluvial	Coarse	18	0	22	72	6
	Medium	7	0	0	86	14
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	29	0	10	59	31
	Average*		0	13	67	20

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 100	100-150	150-200	> 200
			parts per million			
Miss. Terrace	Medium	1561	24	37	25	14
			< 110	110-165	165-220	> 220
			parts per million			
Miss. River Alluvial	Medium	10	40	40	0	20
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	97	17	24	20	39
	Average*		19	25	19	37
			< 110	110-165	165-220	> 220
			parts per million			
Ouachita River Alluvial	Coarse	18	11	39	33	17
	Medium	7	42	29	29	0
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	29	38	17	28	17
	Average*		30	25	30	15

(Continued)

Table 32.-(Continued) Summary of soil test results of soil samples from Franklin Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 55	55-110	110-165	> 165
			--------parts per million--------			
Miss. Terrace	Medium	1561	50	37	10	3
			< 60	60-120	120-180	> 180
			--------parts per million--------			
Miss. River Alluvial	Medium	10	70	30	0	0
			< 80	80-160	160-240	> 240
			--------parts per million--------			
	Fine	97	53	40	5	2
	Average*		54	39	5	2
			< 60	60-120	120-180	> 180
			--------parts per million--------			
Ouachita River Alluvial	Coarse	18	39	55	6	0
	Medium	7	86	14	0	0
			< 80	80-160	160-240	> 240
			--------parts per million--------			
	Fine	29	73	24	3	0
	Average*		62	34	4	0

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 33.-Summary of soil test results of soil samples from Grant Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	334	6	20	33	26	13	2
	Medium	10	17	66	0	0	0	17
	Average*		6	21	32	25	13	3
Red River Alluvial	Coarse	12	0	0	0	64	9	27
	Medium	175	0	2	15	29	14	40
	Fine	104	0	0	9	35	22	34
	Average*		0	1	14	34	15	36

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 300	300-500	500-1000	> 1000
			parts per million			
Coastal Plain	Coarse	334	30	33	27	10
	Medium	10	33	17	17	33
	Average*		30	33	27	10
			< 700	700-1400	1400-2800	>2800
			parts per million			
Red River Alluvial	Coarse	12	27	64	9	0
	Medium	175	18	39	20	23
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	104	8	46	26	20
	Average*		15	42	22	21

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 30	30-50	50-100	>100
			parts per million			
Coastal Plain	Coarse	334	4	7	37	52
	Medium	10	0	0	33	67
	Average*		4	7	37	52
			< 70	70-140	140-280	> 280
			parts per million			
Red River Alluvial	Coarse	12	0	0	73	27
	Medium	175	0	6	25	69
			< 140	140-280	280-450	>450
			parts per million			
	Fine	104	0	1	5	94
	Average*		0	4	20	76

(Continued)

Table 33.-(Continued) Summary of soil test results of soil samples from Grant Parish. 1964-1967.

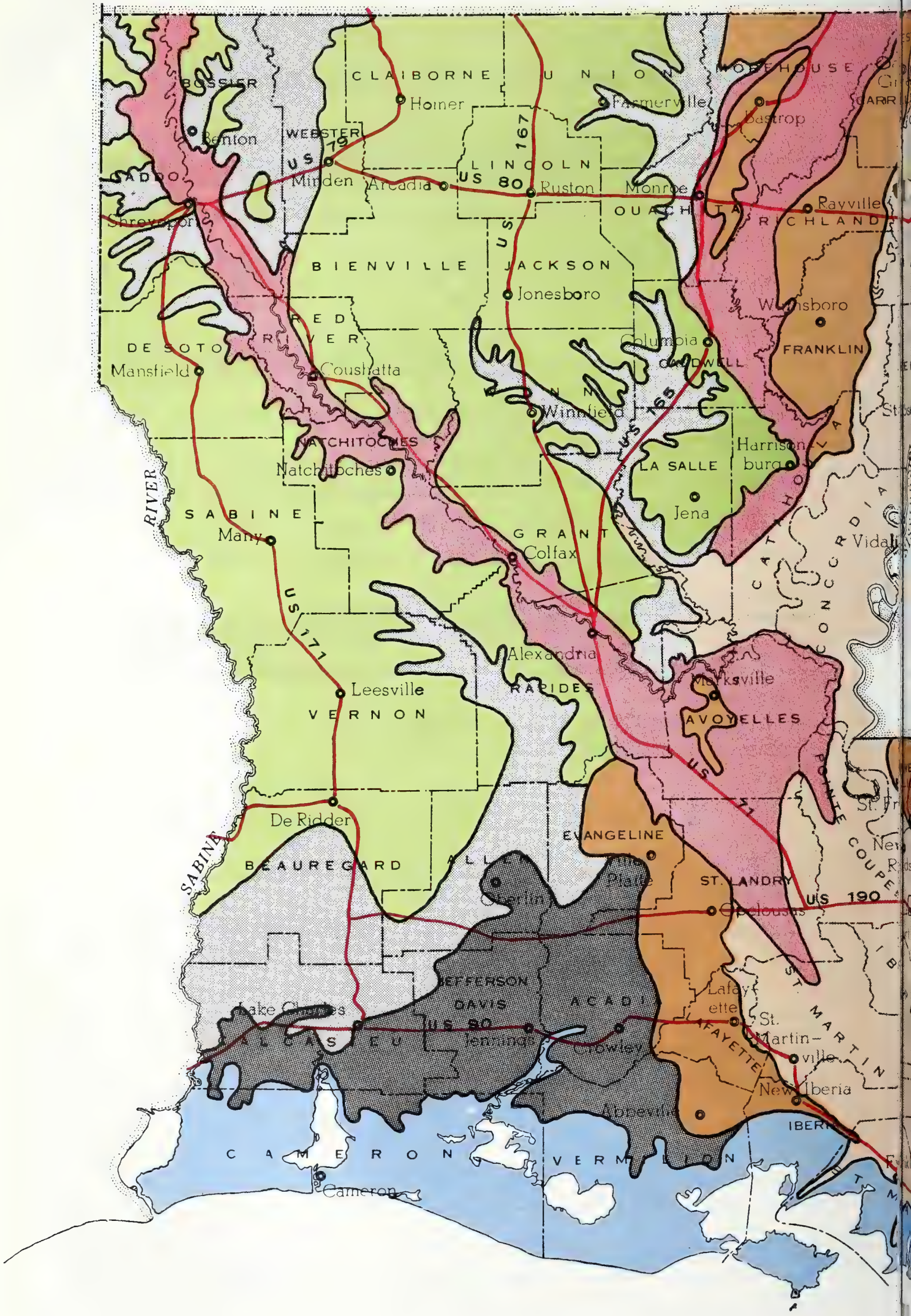
D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 80	80-120	120-160	> 160
			parts per million			
Coastal Plain	Coarse	334	53	28	12	7
	Medium	10	83	0	0	17
	Average*		54	27	12	7
			< 110	110-165	165-220	> 220
			parts per million			
Red River Alluvial	Coarse	12	27	55	9	9
	Medium	175	23	43	22	12
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	104	27	41	22	10
	Average*		24	43	22	11

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 40	40-80	80-120	> 120
			parts per million			
Coastal Plain	Coarse	334	80	11	4	5
	Medium	10	83	0	0	17
	Average*		80	10	4	6
			< 60	60-120	120-180	> 180
			parts per million			
Red River Alluvial	Coarse	12	27	46	27	0
	Medium	175	13	24	36	27
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	104	27	38	23	12
	Average*		19	30	31	20

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.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167
US 80
Arcadia
Ruston
Monroe
OUACHITA
Rayville
RICHLAND
BIENVILLE
JACKSON
Jonesboro
Winnsboro
FRANKLIN
DE SOTO
Mansfield
RED RIVER
Coushatta
Columbia
CALDWELL
WINN
Winnfield
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NATCHITOCHES
Natchitoches
LA SALLE
Jena
Harrisonburg
CATAHOULA
CONCORDIA
Vidalia
SABINE RIVER
SABINE
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GRANT
Colfax
US 171
Alexandria
RAPIDES
Marksville
AVOYELLES
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POINTE COUPEE
New Roads
US 190
JEFFERSON DAVIS
Lake Charles
CALCASIEU
US 90
Jennings
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LAFAYETTE
St. Martinville
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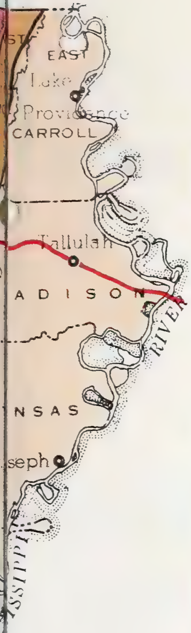
New Iberia
IBERIA
Abbeville
CAMERON
Cameron
VERMILION

GENERAL SOIL AREAS IN LOUISIANA



🟩	GENTLY SLOPING TO HILLY COASTAL PLAIN—Shubuta, Ruston, Bowie, Lucy, Troup, Kirvin, Nacogdoches, Susquehanna, Ora, Sawyer, Boswell, etc., with Cahaba, Prentiss, Stough
🟧	LOESSIAL HILLS AND MISSISSIPPI TERRACES—Olivier, Loring, Memphis, Providence, Lexington, Calhoun, Jeanerette, etc., with Cascilla, Waverly, Collins
▨	FLATWOODS AREAS—Caddo, Beauregard, Acadia, Frost, Calhoun, Zachary, Wrightsville, etc., with Bibb, Waverly
▩	COASTAL PRAIRIES—Crowley, Midland, with Beaumont, Bernard, Acadia
⬜	RECENT ALLUVIUM (MISSISSIPPI RIVER ALLUVIAL SOILS)—Sharkey, Mhoon, Commerce, Tunica, etc., with Cypremort, Dundee, Baldwin, Iberia, Jeanerette
🟥	RECENT ALLUVIUM (ALLUVIAL SOILS OF THE RED AND OUACHITA RIVERS)—Moreland, Norwood, Yahola, Perry, Portland, etc., with Gallion, Hebert, Pulaski
🟦	COASTAL MARSHLANDS—Marsh Peats, Mucks, Clays, and Harris, with Swamp Peats, Mucks, and Clays

Compiled by S. A. Lytle, Associate Professor, Department of Agronomy, Louisiana Agricultural Experiment Station, Baton Rouge, La. OCTOBER 1968

MAP SCALE
1 inch = 31 miles (approx.)
1 : 1989504

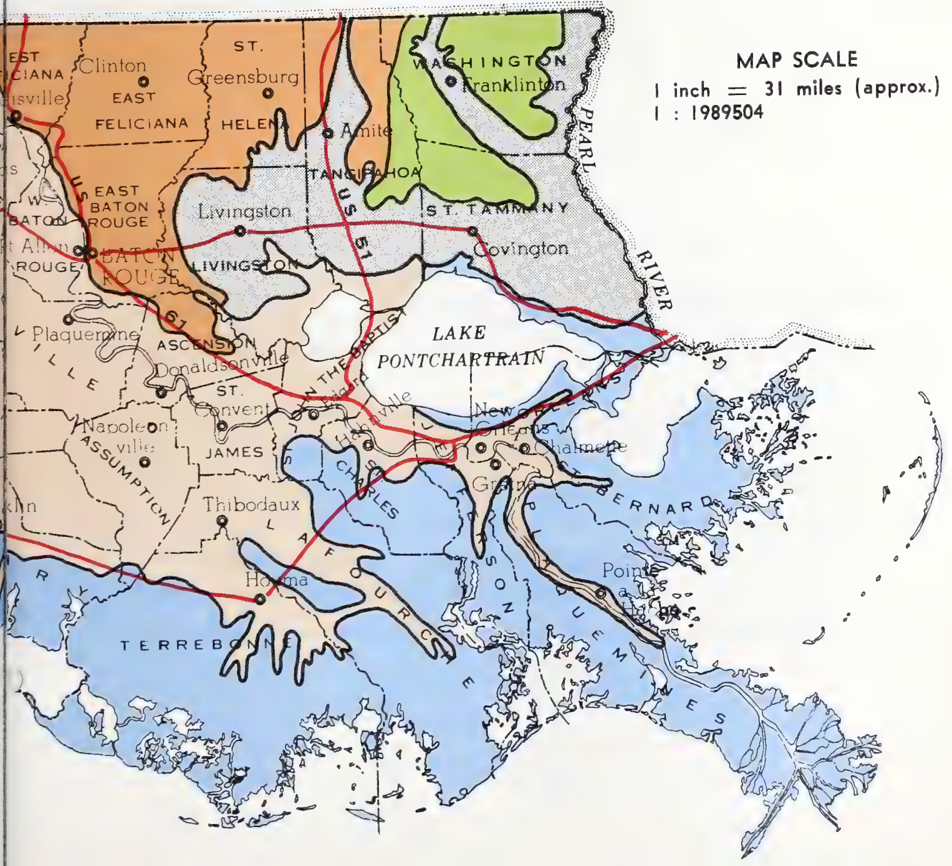


Table 34.-Summary of soil test results of soil samples from Iberia Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Medium	308	8	22	24	24	14	8
	Fine	731	8	15	24	21	15	17
	Average*		8	17	24	22	15	14
Miss. Terrace	Medium	168	21	30	30	13	4	2

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	>2800
			---parts per million---			
Miss. River Alluvial	Medium	308	17	35	36	12
			<1400	1400-2800	2800-4000	>4000
			---parts per million---			
	Fine	731	8	43	33	16
	Average*		11	40	34	15
			< 500	500-1000	1000-2000	>2000
			---parts per million---			
Miss. Terrace	Medium	168	33	46	17	4

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			---parts per million---			
Miss. River Alluvial	Medium	308	0	7	27	66
			<140	140-280	280-450	> 450
			---parts per million---			
	Fine	731	0	3	16	81
	Average*		0	4	19	77
			< 50	50-100	100-200	> 200
			---parts per million---			
Miss. Terrace	Medium	168	0	9	34	57

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			---parts per million---			
Miss. River Alluvial	Medium	308	71	21	3	5
			< 160	160-240	240-320	> 320
			---parts per million---			
	Fine	731	70	19	7	4
	Average*		70	20	6	4
			< 100	100-150	150-200	> 200
			---parts per million---			
Miss. Terrace	Medium	168	65	22	10	3

(Continued)

Table 34.- (Continued) Summary of soil test results of soil samples from Iberia Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	>180
			--------------------parts per million------------------			
Miss. River Alluvial	Medium	308	76	15	5	4
			< 80	80-160	160-240	> 240
			--------------------parts per million------------------			
	Fine	731	76	20	2	2
	Average*		76	18	3	3
			< 55	55-110	110-165	>165
			--------------------parts per million------------------			
Miss. Terrace	Medium	168	88	7	3	2

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 35.-Summary of soil test results of soil samples from Iberville Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Medium	179	0	6	22	35	20	17
	Fine	339	1	1	20	51	23	4
	Average*		1	3	21	45	22	8

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	> 2800
			--------------------parts per million------------------			
Miss. River Alluvial	Medium	179	0	14	75	11
			< 1400	1400-2800	2800-4000	> 4000
			--------------------parts per million------------------			
	Fine	339	1	47	40	12
	Average*		1	36	51	12

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	>280
			--------------------parts per million------------------			
Miss. River Alluvial	Medium	179	0	0	15	85
			< 140	140-280	280-450	> 450
			--------------------parts per million------------------			
	Fine	339	0	1	18	81
	Average*		0	1	17	82

(Continued)

Table 35.- (Continued) Summary of soil test results of soil samples from Iberville Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			--------------------parts	per million-		
Miss. River Alluvial	Medium	179	23	50	16	11
			< 160	160-240	240-320	> 320
			--------------------parts	per million-		
	Fine	339	29	41	21	9
	Average*		27	44	19	10

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			--------------------parts	per million-		
Miss. River Alluvial	Medium	179	1	2	24	73
			< 80	80-160	160-240	> 240
			--------------------parts	per million-		
	Fine	339	1	19	54	26
	Average*		1	13	44	42

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 36.-Summary of soil test results of soil samples from Jackson Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Coastal Plain	Coarse	28	4	21	18	25	18	14

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 300	300-500	500-1000	> 1000
			--------------------parts	per million-		
Coastal Plain	Coarse	28	21	36	18	25

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 30	30-50	50-100	> 100
			--------------------parts	per million-		
Coastal Plain	Coarse	28	32	7	36	25

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 80	80-120	120-160	> 160
			--------------------parts	per million-		
Coastal Plain	Coarse	28	21	44	21	14

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 40	40-80	80-120	> 120
			--------------------parts	per million-		
Coastal Plain	Coarse	28	29	25	14	32

Table 37.-Summary of soil test results of soil samples from Jefferson Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Medium	6	0	0	0	20	40	40
	Fine	16	0	13	37	19	18	13
	Average*		0	9	28	18	27	18

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	>2800
			parts per million			
Miss. River Alluvial	Medium	6	0	0	60	40
			< 1400	1400-2800	2800-4000	>4000
			parts per million			
	Fine	16	0	24	38	38
	Average*		0	18	46	36

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			parts per million			
Miss. River Alluvial	Medium	6	0	0	0	100
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	16	0	0	0	100
	Average*		0	0	0	100

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			parts per million			
Miss. River Alluvial	Medium	6	20	60	0	20
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	16	25	19	31	25
	Average*		23	31	23	23

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			parts per million			
Miss. River Alluvial	Medium	6	0	0	0	100
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	16	13	25	31	31
	Average*		9	18	23	50

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 38.-Summary of soil test results of soil samples from Jefferson Davis Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Prairie	Coarse	12	0	38	38	24	0	0
	Medium	384	13	39	30	12	4	2
	Fine	84	12	36	33	11	4	4
	Average*		13	38	31	12	4	2
Flatwoods	Coarse	5	20	60	0	0	0	20
	Medium	19	37	37	21	0	5	0
	Average*		33	42	17	0	4	4

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 600	600-1200	1200-2400	> 2400
			parts per million			
Coastal Prairie	Coarse	12	88	12	0	0
	Medium	384	50	37	11	2
	Fine	84	7	32	52	9
	Average*		44	35	18	3
			< 400	400-800	800-1600	> 1600
			parts per million			
Flatwoods	Coarse	5	60	20	0	20
	Medium	19	69	26	0	5
	Average*		67	25	0	8

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-240	> 240
			parts per million			
Coastal Prairie	Coarse	12	0	24	63	13
	Medium	384	2	30	44	24
	Fine	84	0	2	6	92
	Average*		2	25	38	35
			< 40	40-80	80-160	> 160
			parts per million			
Flatwoods	Coarse	5	0	60	40	0
	Medium	19	0	16	63	21
	Average*		0	25	58	17

(Continued)

Table 38.-(Continued) Summary of soil test results of soil samples from Jefferson Davis Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <100	100-150	150-200	>200
			--------------------parts per million			------------------
Coastal Prairie	Coarse	12	100	0	0	0
	Medium	384	66	26	5	3
	Fine	84	38	40	11	11
	Average*		61	27	6	6

Soil Area	Soil Texture	No. of Samples	<80	80-120	120-160	>160
			---------------------parts per million			----------------
Flatwoods	Coarse	5	40	20	20	20
	Medium	19	69	26	5	0
	Average*		63	25	8	4

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <35	35-70	70-105	>105
			-------------------parts per million			-----------------
Coastal Prairie	Coarse	12	75	25	0	0
	Medium	384	78	15	3	4
	Fine	84	87	7	5	1
	Average*		80	14	3	3

Soil Area	Soil Texture	No. of Samples	<35	35-70	70-105	>105
			-------------------parts per million			-----------------
Flatwoods	Coarse	5	60	0	20	20
	Medium	19	95	5	0	0
	Average*		88	4	4	4

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 39.-Summary of soil test results of soil samples from Lafayette Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Miss. Terrace	Medium	265	12	32	20	19	11	6
Miss. River Alluvial	Medium	8	0	0	83	17	0	0
	Fine	52	4	11	35	21	19	10
	Average*		3	10	42	20	17	8

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 500	500-1000	1000-2000	> 2000
			parts per million			
Miss. Terrace	Medium	265	36	30	28	6
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Miss. River Alluvial	Medium	8	17	50	33	0
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	52	2	41	42	15
	Average*		3	42	42	13

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 50	50-100	100-200	> 200
			parts per million			
Miss. Terrace	Medium	265	2	14	47	37
			< 70	70-140	140-280	> 280
			parts per million			
Miss. River Alluvial	Medium	8	0	17	17	66
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	52	0	4	19	77
	Average*		0	5	18	77

(Continued)

Table 39.-(Continued) Summary of soil test results of soil samples from Lafayette Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 100	100-150	150-200	> 200
			parts per million			
Miss. Terrace	Medium	265	58	26	8	8
			< 110	110-165	165-220	> 220
			parts per million			
Miss. River Alluvial	Medium	8	67	33	0	0
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	52	52	27	19	2
	Average*		53	28	17	2

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 55	55-110	110-165	> 165
			parts per million			
Miss. Terrace	Medium	265	78	14	4	4
			< 60	60-120	120-180	> 180
			parts per million			
Miss. River Alluvial	Medium	8	83	17	0	0
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	52	60	36	0	4
	Average*		63	34	0	3

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 40.-Summary of soil test results of soil samples from Lafourche Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Coarse	3	0	0	33	0	34	33
	Medium	76	1	6	21	22	16	34
	Fine	185	1	8	24	36	16	15
	Average*		1	7	22	29	21	20

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Miss. River Alluvial	Coarse	3	0	0	100	0
	Medium	76	1	3	81	15
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	185	1	32	40	27
	Average*		1	23	53	23

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			parts per million			
Miss. River Alluvial	Coarse	3	0	0	0	100
	Medium	76	0	0	2	98
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	185	0	0	9	91
	Average*		0	0	7	93

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			parts per million			
Miss. River Alluvial	Coarse	3	33	34	0	33
	Medium	76	30	59	6	5
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	185	35	36	21	8
	Average*		34	42	16	8

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			parts per million			
Miss. River Alluvial	Coarse	3	0	0	33	67
	Medium	76	2	7	25	66
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	185	3	38	43	16
	Average*		3	28	38	31

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 41.-Summary of soil test results of soil samples from LaSalle Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	89	12	30	22	17	15	4
	Medium	5	33	34	33	0	0	0
	Average*		13	31	22	16	14	4
Miss. River Alluvial	Medium	2	0	50	50	0	0	0
	Fine	9	11	56	11	11	0	11
	Average*		9	55	18	9	0	9

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<300	300-500	500-1000	>1000
			parts per million			
Coastal Plain	Coarse	89	17	25	41	17
	Medium	5	0	67	33	0
	Average*		16	26	42	16
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Miss. River Alluvial	Medium	2	0	100	0	0
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	9	0	78	11	11
	Average*		0	82	9	9

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<30	30-50	50-100	>100
			parts per million			
Coastal Plain	Coarse	89	0	4	17	79
	Medium	5	0	0	33	67
	Average*		0	4	18	78
			< 70	70-140	140-280	>280
			parts per million			
Miss. River Alluvial	Medium	2	0	0	50	50
			<140	140-280	280-450	>450
			parts per million			
	Fine	9	0	0	44	56
	Average*		0	0	45	55

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 80	80-120	120-160	>160
			parts per million			
Coastal Plain	Coarse	89	39	31	12	18
	Medium	5	67	0	33	0
	Average*		39	30	14	17
			<110	110-165	165-220	>220
			parts per million			
Miss. River Alluvial	Medium	2	0	50	50	0
			<160	160-240	240-320	> 320
			parts per million			
	Fine	9	11	45	33	11
	Average*		9	45	36	10

(Continued)

Table 41.- (Continued) Summary of soil test results of soil samples from LaSalle Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<40	40-80	80-120	>120
			parts per million			
Coastal Plain	Coarse	89	85	8	1	6
	Medium	5	100	0	0	0
	Average*		87	7	1	5
			< 60	60-120	120-180	>180
			parts per million			
Miss. River Alluvial	Medium	2	0	0	100	0
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	9	67	22	11	0
	Average*		55	18	27	0

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 42.-Summary of soil test results of soil samples from Lincoln Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Coastal Plain	Coarse	347	3	9	31	32	22	3

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 300	300-500	500-1000	>1000
			parts per million			
Coastal Plain	Coarse	347	27	27	32	14

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 30	30-50	50-100	>100
			parts per million			
Coastal Plain	Coarse	347	6	13	33	48

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 80	80-120	120-160	>160
			parts per million			
Coastal Plain	Coarse	347	25	30	25	20

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 40	40-80	80-120	>120
			parts per million			
Coastal Plain	Coarse	347	51	26	10	13

Table 43.-Summary of soil test results of soil samples from Livingston Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Flatwoods	Coarse	136	7	37	19	21	12	4
	Medium	29	28	34	14	17	7	0
	Average*		11	36	18	21	11	3
Miss. Terrace	Medium	219	11	27	29	20	10	3

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 400	400-800	800-1600	>1600
			-------------------parts per million-----------------			
Flatwoods	Coarse	136	32	34	24	10
	Medium	29	34	45	21	0
	Average*		33	35	24	8
			< 500	500-1000	1000-2000	> 2000
			-------------------parts per million-----------------			
Miss. Terrace	Medium	219	37	43	18	2

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 40	40-80	80-160	>160
			-------------------parts per million-----------------			
Flatwoods	Coarse	136	5	15	48	32
	Medium	29	1	17	34	48
	Average*		5	15	45	35
			< 50	50-100	100-200	> 200
			-------------------parts per million-----------------			
Miss. Terrace	Medium	219	3	26	42	29

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 80	80-120	120-160	>160
			-------------------parts per million-----------------			
Flatwoods	Coarse	136	33	25	17	25
	Medium	29	59	10	17	14
	Average*		38	22	17	23
			< 100	100-150	150-200	>200
			-------------------parts per million-----------------			
Miss. Terrace	Medium	219	62	22	10	6

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 35	35-70	70-105	> 105
			-------------------parts per million-----------------			
Flatwoods	Coarse	136	32	7	7	54
	Medium	29	62	7	3	28
	Average*		38	7	7	48
			< 55	55-110	110-165	>165
			-------------------parts per million-----------------			
Miss. Terrace	Medium	219	60	16	6	18

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 44.-Summary of soil test results of soil samples from Madison Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Medium	164	2	8	25	30	15	20
	Fine	339	1	5	26	41	9	18
	Average*		1	6	26	37	11	19

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<700	700-1400	1400-2800	>2800
			--------------------parts	per million	------------------	
Miss. River Alluvial	Medium	164	0	15	63	22
			<1400	1400-2800	2800-4000	>4000
			--------------------parts	per million	------------------	
	Fine	339	1	33	39	27
	Average*		0	27	48	25

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<70	70-140	140-280	>280
			--------------------parts	per million	------------------	
Miss. River Alluvial	Medium	164	0	0	24	76
			<140	140-280	280-450	>450
			--------------------parts	per million	------------------	
	Fine	339	1	2	15	82
	Average*		1	1	18	80

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			--------------------parts	per million	------------------	
Miss. River Alluvial	Medium	164	4	18	31	47
			<160	160-240	240-320	>320
			--------------------parts	per million	------------------	
	Fine	339	6	20	32	42
	Average*		5	19	32	44

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			--------------------parts	per million	------------------	
Miss. River Alluvial	Medium	164	6	11	7	76
			<80	80-160	160-240	>240
			--------------------parts	per million	------------------	
	Fine	339	11	32	23	34
	Average*		9	25	18	48

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 45.-Summary of soil test results of soil samples from Morehouse Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Ouachita River Alluvial	Coarse	146	18	14	25	24	12	7
	Medium	1319	5	13	26	29	21	6
	Fine	383	26	19	19	17	13	6
	Average*		10	14	25	26	19	6
Miss. Terrace	Medium	90	6	25	35	14	14	6

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	>2800
			parts per million			
Ouachita River Alluvial	Coarse	146	66	22	10	2
	Medium	1319	41	40	17	2
			<1400	1400-2800	2800-4000	>4000
			parts per million			
	Fine	383	33	41	18	8
	Average*		41	39	17	3
			< 500	500-1000	1000-2000	>2000
			parts per million			
Miss. Terrace	Medium	90	42	48	9	1

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<70	70-140	140-280	>280
			parts per million			
Ouachita River Alluvial	Coarse	146	7	43	38	12
	Medium	1319	4	24	51	21
			<140	140-280	280-450	>450
			parts per million			
	Fine	383	2	14	25	59
	Average*		4	23	45	28
			<50	50-100	100-200	>200
			parts per million			
Miss. Terrace	Medium	90	0	12	52	36

(Continued)

Table 45.-(Continued) Summary of soil test results of soil samples from Morehouse Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			parts per million			
Ouachita River Alluvial	Coarse	146	35	32	18	15
	Medium	1319	22	38	25	15
			<160	160-240	240-320	>320
			parts per million			
	Fine	383	30	31	20	19
	Average*		25	36	23	16
			<100	100-150	150-200	>200
			parts per million			
Miss. Terrace	Medium	90	19	39	23	19

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	>180
			parts per million			
Ouachita River Alluvial	Coarse	146	57	24	8	11
	Medium	1319	34	48	13	5
			< 80	80-160	160-240	>240
			parts per million			
	Fine	383	62	31	5	2
	Average*		42	42	11	5
			<55	55-110	110-165	>165
			parts per million			
Miss. Terrace	Medium	90	67	24	2	7

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 46.-Summary of soil test results of soil samples from Natchitoches Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Red River Alluvial	Coarse	17	6	0	18	46	6	24
	Medium	423	1	2	7	20	15	55
	Fine	385	2	1	9	30	21	37
	Average*		2	1	8	25	18	46
Coastal Plain	Coarse	208	8	20	28	19	18	7
	Medium	10	10	40	0	30	20	0
	Average*		8	21	27	19	18	7

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 700	700-1400	1400-2800	> 2800
			--------parts	per	million--------	
Red River Alluvial	Coarse	17	41	29	18	12
	Medium	423	11	32	26	31
			< 1400	1400-2800	2800-4000	> 4000
			--------parts	per	million--------	
	Fine	385	8	33	33	26
	Average*		10	32	29	29
			< 300	300-500	500-1000	> 1000
			--------parts	per	million--------	
Coastal Plain	Coarse	208	25	24	31	20
	Medium	10	10	0	20	70
	Average*		24	23	30	23

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 70	70-140	140-280	> 280
			--------parts	per	million--------	
Red River Alluvial	Coarse	17	6	0	53	41
	Medium	423	0	2	20	78
			< 140	140-280	280-450	> 450
			--------parts	per	million--------	
	Fine	385	1	1	5	93
	Average*		1	2	14	83
			< 30	30-50	50-100	>100
			--------parts	per	million--------	
Coastal Plain	Coarse	208	3	8	25	64
	Medium	10	0	0	0	100
	Average*		3	8	24	65

(Continued)

Table 46.-(Continued) Summary of soil test results of soil samples from Natchitoches Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			parts per million			
Red River Alluvial	Coarse	17	59	18	6	17
	Medium	423	17	44	28	11
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	385	19	38	25	18
	Average*		19	41	26	14
			< 80	80-120	120-160	> 160
			parts per million			
Coastal Plain	Coarse	208	38	33	17	12
	Medium	10	20	50	20	10
	Average*		37	34	17	12

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			parts per million			
Red River Alluvial	Coarse	17	0	59	29	12
	Medium	423	6	24	42	28
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	385	21	39	29	11
	Average*		13	32	35	20
			< 40	40-80	80-120	> 120
			parts per million			
Coastal Plain	Coarse	208	73	15	7	5
	Medium	10	70	30	0	0
	Average*		72	16	7	5

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 47.-Summary of soil test results of soil samples from Orleans Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Medium	3	33	0	0	0	0	67
	Fine	3	0	0	0	0	0	100
	Average*		17	0	0	0	0	83

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<700	700-1400	1400-2800	>2800
			--------parts per million--------			
Miss. River Alluvial	Medium	3	33	0	0	67
			<1400	1400-2800	2800-4000	>4000
			--------parts per million--------			
	Fine	3	0	0	0	100
	Average*		17	0	0	83

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<70	70-140	140-280	>280
			--------parts per million--------			
Miss. River Alluvial	Medium	3	0	0	0	100
			<140	140-280	280-450	>450
			--------parts per million--------			
	Fine	3	0	0	0	100
	Average*		0	0	0	100

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			--------parts per million--------			
Miss. River Alluvial	Medium	3	33	0	0	67
			<160	160-240	240-320	>320
			--------parts per million--------			
	Fine	3	0	0	0	100
	Average*		17	0	0	83

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			--------parts per million--------			
Miss. River Alluvial	Medium	3	33	0	0	67
			<80	80-160	160-240	>240
			--------parts per million--------			
	Fine	3	0	0	100	0
	Average*		17	0	50	33

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 48.-Summary of soil test results of soil samples from Ouachita Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Ouachita River Alluvial	Coarse	32	0	25	34	16	16	9
	Medium	642	4	19	24	29	18	6
	Fine	159	32	22	17	20	8	1
	Average*		9	20	23	27	16	5
Coastal Plain	Coarse	254	6	20	21	22	22	9
	Medium	12	13	25	38	12	12	0
	Average*		6	20	23	21	21	9

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	>2800
			------------------parts per million-----------------			
Ouachita River Alluvial	Coarse	32	56	28	13	3
	Medium	642	40	50	10	0
			<1400	1400-2800	2800-4000	>4000
			------------------parts per million-----------------			
	Fine	159	46	43	9	2
	Average*		42	47	10	1
			< 300	300-500	500-1000	>1000
			------------------parts per million-----------------			
Coastal Plain	Coarse	254	26	27	37	10
	Medium	12	25	50	13	12
	Average*		26	28	36	10

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			------------------parts per million-----------------			
Ouachita River Alluvial	Coarse	32	3	25	50	22
	Medium	642	2	25	49	24
			< 140	140-280	280-450	> 450
			------------------parts per million-----------------			
	Fine	159	3	15	38	44
	Average*		2	23	47	28
			< 30	30-50	50-100	>100
			------------------parts per million-----------------			
Coastal Plain	Coarse	254	5	10	37	48
	Medium	12	0	0	38	62
	Average*		5	9	37	49

(Continued)

Table 48.-(Continued) Summary of soil test results of soil samples from Ouachita Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			parts per million			
Ouachita River Alluvial	Coarse	32	28	37	22	13
	Medium	642	23	40	24	13
			<160	160-240	240-320	>320
			parts per million			
	Fine	159	35	34	18	13
	Average*		25	39	23	13
			<80	80-120	120-160	>160
			parts per million			
Coastal Plain	Coarse	254	33	34	16	17
	Medium	12	37	13	37	13
	Average*		33	33	17	17

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			parts per million			
Ouachita River Alluvial	Coarse	32	44	34	9	13
	Medium	642	22	40	26	12
			<80	80-160	160-240	>240
			parts per million			
	Fine	159	52	29	15	4
	Average*		29	38	23	10
			<40	40-80	80-120	>120
			parts per million			
Coastal Plain	Coarse	254	64	17	6	13
	Medium	12	38	25	25	12
	Average*		63	17	7	13

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 49.-Summary of soil test results of soil samples from Plaquemines Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Medium	9	0	0	0	13	0	87
	Fine	67	0	6	13	13	18	50
	Average*		0	5	11	13	16	55

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	>2800
			---parts per million---			
Miss. River Alluvial	Medium	9	0	0	13	87
			< 1400	1400-2800	2800-4000	> 4000
			---parts per million---			
	Fine	67	0	39	52	9
	Average*		0	34	48	18

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			---parts per million---			
Miss. River Alluvial	Medium	9	0	0	0	100
			< 140	140-280	280-450	> 450
			---parts per million---			
	Fine	67	0	0	0	100
	Average*		0	0	0	100

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			---parts per million---			
Miss. River Alluvial	Medium	9	13	12	13	62
			< 160	160-240	240-320	> 320
			---parts per million---			
	Fine	67	13	31	22	34
	Average*		13	28	21	38

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			---parts per million---			
Miss. River Alluvial	Medium	9	0	0	0	100
			< 80	80-160	160-240	> 240
			---parts per million---			
	Fine	67	0	3	13	84
	Average*		0	3	12	85

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 50.-Summary of soil test results of soil samples from Pointe Coupee Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Coarse	17	0	0	0	27	20	53
	Medium	261	0	8	30	30	18	14
	Fine	251	0	7	36	35	12	10
	Average*		0	7	32	32	16	13

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<700	700-1400	1400-2800	>2800
			--------parts	per	million--------	
Miss. River Alluvial	Coarse	17	0	53	40	7
	Medium	261	3	25	59	13
			<1400	1400-2800	2800-4000	>4000
			--------parts	per	million--------	
	Fine	251	0	48	39	13
	Average*		2	37	48	13

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<70	70-140	140-280	>280
			--------parts	per	million--------	
Miss. River Alluvial	Coarse	17	0	0	33	67
	Medium	261	0	3	19	78
			<140	140-280	280-450	>450
			--------parts	per	million--------	
	Fine	251	0	1	12	87
	Average*		0	2	16	82

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			--------parts	per	million--------	
Miss. River Alluvial	Coarse	17	0	7	27	66
	Medium	261	15	26	29	30
			<160	160-240	240-320	>320
			--------parts	per	million--------	
	Fine	251	19	35	25	21
	Average*		16	30	27	27

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			--------parts	per	million--------	
Miss. River Alluvial	Coarse	17	0	0	20	80
	Medium	261	2	10	29	59
			<80	80-160	160-240	>240
			--------parts	per	million--------	
	Fine	251	6	43	33	18
	Average*		4	25	31	40

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 51.-Summary of soil test results of soil samples from Rapides Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Red River Alluvial	Coarse	17	0	0	34	29	22	15
	Medium	602	0	0	5	10	17	68
	Fine	229	0	0	3	12	24	61
	Average*		0	0	5	11	19	65
Coastal Plain	Coarse	234	9	30	29	21	8	3
	Medium	50	11	48	16	11	9	5
	Average*		10	32	27	19	8	4
Miss. Terrace	Medium	29	4	32	21	32	7	4

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 300	300-500	500-1000	> 1000
			parts per million			
Coastal Plain	Coarse	234	24	25	35	16
	Medium	50	7	36	34	23
	Average*		21	27	35	17
			< 500	500-1000	1000-2000	> 2000
			parts per million			
Miss. Terrace	Medium	29	25	39	29	7
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Red River Alluvial	Coarse	17	27	47	13	13
	Medium	602	7	26	31	36
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	229	4	15	25	56
	Average*		7	23	29	41

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 30	30-50	50-100	> 100
			parts per million			
Coastal Plain	Coarse	234	1	7	28	64
	Medium	50	2	3	27	68
	Average*		1	6	28	65
			< 50	50-100	100-200	> 200
			parts per million			
Miss. Terrace	Medium	29	0	11	57	32
			< 70	70-140	140-280	> 280
			parts per million			
Red River Alluvial	Coarse	17	0	13	47	40
	Medium	602	0	1	23	76
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	229	0	1	3	96
	Average*		0	1	18	81

(Continued)

Table 51.- (Continued) Summary of soil test results of soil samples from Rapides Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 80	80-120	120-160	>160
			parts per million			
Coastal Plain	Coarse	234	48	24	17	11
	Medium	50	48	23	11	18
	Average*		48	24	16	12
			< 100	100-150	150-200	> 200
			parts per million			
Miss. Terrace	Medium	29	36	32	18	14
			< 110	110-165	165-220	> 220
			parts per million			
Red River Alluvial	Coarse	17	20	40	20	20
	Medium	602	18	37	28	17
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	229	22	32	26	20
	Average*		19	36	27	18

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 40	40-80	80-120	>120
			parts per million			
Coastal Plain	Coarse	234	68	19	5	8
	Medium	50	89	0	2	9
	Average*		72	15	5	8
			< 55	55-110	110-165	>165
			parts per million			
Miss. Terrace	Medium	29	92	0	4	4
			< 60	60-120	120-180	> 180
			parts per million			
Red River Alluvial	Coarse	17	20	34	33	13
	Medium	602	2	11	45	42
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	229	10	37	43	10
	Average*		4	19	44	33

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 52.-Summary of soil test results of soil samples from Red River Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Red River Alluvial	Coarse	2	0	0	0	0	50	50
	Medium	129	1	3	11	29	12	44
	Fine	143	2	0	4	39	34	21
	Average*		1	1	7	34	25	32
Coastal Plain	Coarse	243	4	17	22	36	18	3

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 700	700-1400	1400-2800	> 2800
			--------parts	per million--------		
Red River Alluvial	Coarse	2	50	0	0	50
	Medium	129	10	32	29	29
			< 1400	1400-2800	2800-4000	> 4000
			--------parts	per million--------		
	Fine	143	9	58	24	9
	Average*		10	45	26	19
			< 300	300-500	500-1000	> 1000
			--------parts	per million--------		
Coastal Plain	Coarse	243	50	23	21	6

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 70	70-140	140-280	> 280
			--------parts	per million--------		
Red River Alluvial	Coarse	2	0	0	50	50
	Medium	129	1	3	17	79
			< 140	140-280	280-450	> 450
			--------parts	per million--------		
	Fine	143	1	0	8	91
	Average*		1	1	12	86
			< 30	30-50	50-100	> 100
			--------parts	per million--------		
Coastal Plain	Coarse	243	12	15	45	28

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 110	110-165	165-220	> 220
			--------parts	per million--------		
Red River Alluvial	Coarse	2	0	100	0	0
	Medium	129	20	33	28	19
			< 160	160-240	240-320	> 320
			--------parts	per million--------		
	Fine	143	28	36	27	9
	Average*		24	35	27	14
			< 80	80-120	120-160	> 160
			--------parts	per million--------		
Coastal Plain	Coarse	243	48	31	12	9

(Continued)

Table 52.- (Continued) Summary of soil test results of soil samples from Red River Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 60	60-120	120-180	>180
			parts per million			
Red River Alluvial	Coarse	2	50	50	0	0
	Medium	129	9	33	47	11
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	143	19	54	20	7
	Average*		15	43	33	9
			< 40	40-80	80-120	> 120
			parts per million			
Coastal Plain	Coarse	243	76	11	3	10

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 53.-Summary of soil test results of soil samples from Richland Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Ouachita River Alluvial	Coarse	129	1	25	31	29	14	0
	Medium	349	4	22	24	34	14	2
	Fine	202	16	33	27	15	7	2
	Average*		7	29	27	28	7	2
Miss. Terrace	Medium	552	9	36	29	18	7	1
Miss. River Alluvial	Medium	8	0	50	38	12	0	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: < 700	700-1400	1400-2800	> 2800
			parts per million			
Ouachita River Alluvial	Coarse	129	58	34	8	0
	Medium	349	59	27	14	0
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	202	21	56	13	10
	Average*		48	36	13	3
			< 500	500-1000	1000-2000	> 2000
			parts per million			
Miss. Terrace	Medium	552	36	45	17	2
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Miss. River Alluvial	Medium	8	25	12	50	13

(Continued)

Table 53.- (Continued) Summary of soil test results of soil samples from Richland Parish. 1964-1967.

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			parts per million			
Ouachita River Alluvial	Coarse	129	6	33	42	19
	Medium	349	7	30	48	15
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	202	2	7	30	61
	Average*		5	24	41	30
			< 50	50-100	100-200	> 200
			parts per million			
Miss. Terrace	Medium	552	3	14	45	38
			< 70	70-140	140-280	> 280
			parts per million			
Miss. River Alluvial	Medium	8	0	0	38	62

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			parts per million			
Ouachita River Alluvial	Coarse	129	26	50	14	10
	Medium	349	27	40	24	9
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	202	42	23	15	20
	Average*		34	36	18	12
			< 100	100-150	150-200	> 200
			parts per million			
Miss. Terrace	Medium	552	22	42	25	11
			< 110	110-165	165-220	> 220
			parts per million			
Miss. River Alluvial	Medium	8	62	25	0	13

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			parts per million			
Ouachita River Alluvial	Coarse	129	57	32	9	2
	Medium	349	30	40	25	5
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	202	69	23	5	3
	Average*		47	33	16	4
			< 55	55-110	110-165	> 165
			parts per million			
Miss. Terrace	Medium	552	52	34	10	4
			< 60	60-120	120-180	> 180
			parts per million			
Miss. River Alluvial	Medium	8	38	62	0	0

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 54.-Summary of soil test results of soil samples from Sabine Parish. 1964-1967.

A. Soil Reaction(pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	123	7	21	28	24	15	5

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<300	300-500	500-1000	>1000
			parts per million			
Coastal Plain	Coarse	123	21	25	33	21

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<30	30-50	50-100	>100
			parts per million			
Coastal Plain	Coarse	123	6	9	31	54

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<80	80-120	120-160	>160
			parts per million			
Coastal Plain	Coarse	123	41	34	16	9

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<40	40-80	80-120	>120
			parts per million			
Coastal Plain	Coarse	123	55	24	8	13

Table 55.-Summary of soil test results of soil samples from St. Bernard Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Medium	5	0	0	0	0	50	50
	Fine	11	9	0	18	27	0	46
	Average*		6	0	12	19	19	44

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<700	700-1400	1400-2800	>2800
			parts per million			
Miss. River Alluvial	Medium	5	0	0	75	25
			<1400	1400-2800	2800-4000	>4000
			parts per million			
	Fine	11	0	36	27	37
	Average*		0	25	44	31

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<70	70-140	140-280	>280
			parts per million			
Miss. River Alluvial	Medium	5	0	0	0	100
			<140	140-280	280-450	>450
			parts per million			
	Fine	11	0	0	9	91
	Average*		0	0	6	94

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			parts per million			
Miss. River Alluvial	Medium	5	25	25	0	50
			<160	160-240	240-320	>320
			parts per million			
	Fine	11	9	37	18	36
	Average*		13	31	18	38

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			parts per million			
Miss. River Alluvial	Medium	5	0	0	0	100
			<80	80-160	160-240	>240
			parts per million			
	Fine	11	0	46	36	18
	Average*		0	31	25	44

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 56.-Summary of soil test results of soil samples from St. Charles Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Medium	12	0	17	33	0	8	42
	Fine	20	0	5	40	35	15	5
	Average*		0	9	38	21	13	19

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	>2800
			parts per million			
Miss. River Alluvial	Medium	12	0	0	83	17
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	20	0	50	35	15
	Average*		0	31	53	16

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	>280
			parts per million			
Miss. River Alluvial	Medium	12	0	0	17	83
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	20	0	0	10	90
	Average*		0	0	12	88

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			parts per million			
Miss. River Alluvial	Medium	12	67	8	0	25
			<160	160-240	240-320	> 320
			parts per million			
	Fine	20	50	20	20	10
	Average*		55	16	13	16

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	>180
			parts per million			
Miss. River Alluvial	Medium	12	0	0	0	100
			< 80	80-160	160-240	>240
			parts per million			
	Fine	20	5	15	45	35
	Average*		3	9	28	60

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 57.-Summary of soil test results of soil samples from St. Helena Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Loessial Hills	Coarse	429	24	35	20	14	6	1
	Medium	56	20	44	18	16	2	0
	Average*		24	35	20	14	6	1
Flatwoods	Coarse	55	31	31	15	13	10	0
	Medium	5	20	0	60	20	0	0
	Average*		30	29	18	13	10	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <500	500-1000	1000-2000	>2000
			------parts	per	million------	
Loessial Hills	Coarse	429	71	19	7	3
	Medium	56	74	16	10	0
	Average*		71	19	7	3
			< 400	400-800	800-1600	>1600
			------parts	per	million------	
Flatwoods	Coarse	55	64	19	15	2
	Medium	5	20	40	40	0
	Average*		61	20	17	2

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <50	50-100	100-200	>200
			------parts	per	million------	
Loessial Hills	Coarse	429	16	37	28	19
	Medium	56	6	52	32	10
	Average*		15	39	28	18
			< 40	40-80	80-160	>160
			------parts	per	million------	
Flatwoods	Coarse	55	8	25	46	21
	Medium	5	0	0	40	60
	Average*		7	23	45	25

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <100	100-150	150-200	>200
			------parts	per	million------	
Loessial Hills	Coarse	429	56	28	9	7
	Medium	56	56	32	10	2
	Average*		56	28	9	7
			< 80	80-120	120-160	>160
			------parts	per	million------	
Flatwoods	Coarse	55	33	38	17	12
	Medium	5	40	0	20	40
	Average*		33	35	17	15

(Continued)

Table 57.- (Continued) Summary of soil test results of soil samples from St. Helena Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 55	55-110	110-165	> 165
			parts per million			
Loessial Hills	Coarse	429	60	27	7	6
	Medium	56	84	14	2	0
	Average*		63	26	6	5
			< 35	35-70	70-105	> 105
			parts per million			
Flatwoods	Coarse	55	46	31	13	10
	Medium	5	60	20	20	0
	Average*		47	30	13	10

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 58.-Summary of soil test results of soil samples from St. James Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Miss. River Alluvial	Coarse	2	0	0	0	0	50	50
	Medium	89	6	18	28	19	10	19
	Fine	108	1	8	36	33	14	8
	Average*		3	13	31	26	13	14

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Miss. River Alluvial	Coarse	2	0	0	50	50
	Medium	89	0	34	59	7
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	108	2	44	40	14
	Average*		1	39	49	11

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			parts per million			
Miss. River Alluvial	Coarse	2	0	0	0	100
	Medium	89	0	1	25	74
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	108	0	1	16	83
	Average*		0	1	20	79

(Continued)

Table 58.- (Continued) Summary of soil test results of soil samples from St. James Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			parts per million			
Miss. River Alluvial	Coarse	2	100	0	0	0
	Medium	89	65	27	7	1
			<160	160-240	240-320	>320
			parts per million			
	Fine	108	35	42	20	3
	Average*		49	35	14	2

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			parts per million			
Miss. River Alluvial	Coarse	2	0	0	50	50
	Medium	89	2	39	29	30
			<80	80-160	160-240	>240
			parts per million			
	Fine	108	5	51	35	9
	Average*		4	44	34	18

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 59.-Summary of soil test results of soil samples from St. John Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Coarse	2	0	0	0	0	0	100
	Medium	23	4	4	4	13	0	75
	Fine	19	5	47	32	11	0	5
	Average*		5	23	16	11	0	45

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<700	700-1400	1400-2800	>2800
			parts per million			
Miss. River Alluvial	Coarse	2	0	0	50	50
	Medium	23	0	9	35	56
			<1400	1400-2800	2800-4000	>4000
			parts per million			
	Fine	19	0	53	47	0
	Average*		0	27	41	32

(Continued)

Table 59.- (Continued) Summary of soil test results of soil samples from St. John Parish. 1964-1967.

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<70	70-140	140-280	>280
			--parts per million--			
Miss. River Alluvial	Coarse	2	0	0	0	100
	Medium	23	0	0	9	91
			<140	140-280	280-450	>450
			--parts per million--			
	Fine	19	0	0	16	84
	Average*		0	0	11	89

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			--parts per million--			
Miss. River Alluvial	Coarse	2	50	0	50	0
	Medium	23	48	39	0	13
			<160	160-240	240-320	>320
			--parts per million--			
	Fine	19	37	42	16	5
	Average*		43	39	9	9

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			--parts per million--			
Miss. River Alluvial	Coarse	2	0	0	0	100
	Medium	23	4	9	4	83
			<80	80-160	160-240	>240
			--parts per million--			
	Fine	19	5	63	27	5
	Average*		5	32	14	49

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 60.-Summary of soil test results of soil samples from St. Landry Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. Terrace	Medium	663	8	32	29	22	7	2
Miss. River Alluvial	Coarse	6	0	0	17	33	17	33
	Medium	67	0	10	16	24	9	41
	Fine	149	3	28	26	21	8	14
	Average*		2	22	23	22	9	22
Red R. Alluvial	Medium	105	0	21	26	32	17	4
	Fine	19	0	0	42	37	21	0
	Average*		0	19	29	31	18	3
Prairie	Medium	43	0	12	37	19	16	16
	Fine	16	0	6	25	19	38	12
	Average*		0	10	34	19	22	15

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<500	500-1000	1000-2000	>2000
			parts per million			
Miss. Terrace	Medium	663	31	51	16	2
			<700	700-1400	1400-2800	>2800
			parts per million			
Miss. River Alluvial	Coarse	6	0	67	33	0
	Medium	67	6	31	38	25
			<1400	1400-2800	2800-4000	>4000
			parts per million			
	Fine	149	7	59	26	8
	Average*		6	51	30	13
			<700	700-1400	1400-2800	>2800
			parts per million			
Red R. Alluvial	Medium	105	49	39	12	0
			<1400	1400-2800	2800-4000	>4000
			parts per million			
	Fine	19	31	32	37	0
	Average*		46	38	16	0
			<600	600-1200	1200-2400	>2400
			parts per million			
Prairie	Medium	43	26	67	7	0
	Fine	16	0	25	31	44
	Average*		19	55	14	12

(Continued)

Table 60.- (Continued) Summary of soil test results of soil samples from St. Landry Parish. 1964-1967.

C. Extractable Magnesium

			Percentage of samples testing in the following ranges:			
Soil Area	Soil Texture	No. of Samples	< 50	50-100	100-200	> 200
			--------parts per million--------			
Miss. Terrace	Medium	663	1	7	54	38
			< 70	70-140	140-280	> 280
			--------parts per million--------			
Miss. River Alluvial	Coarse	6	0	0	50	50
	Medium	67	0	6	9	85
			< 140	140-280	280-450	> 450
			--------parts per million--------			
	Fine	149	3	2	13	82
	Average*		2	3	13	82
			< 70	70-140	140-280	> 280
			--------parts per million--------			
Red River Alluvial	Medium	105	0	8	44	48
			< 140	140-280	280-450	> 450
			--------parts per million--------			
	Fine	19	0	0	11	89
	Average*		0	6	39	55
			< 60	60-120	120-240	> 240
			--------parts per million--------			
Prairie	Medium	43	0	14	56	30
	Fine	16	0	0	6	94
	Average*		0	10	42	48

D. Extractable Potassium

			Percentage of samples testing in the following ranges:			
Soil Area	Soil Texture	No. of Samples	< 100	100-150	150-200	> 200
			--------parts per million--------			
Miss. Terrace	Medium	663	37	35	16	12
			< 110	110-165	165-220	> 220
			--------parts per million--------			
Miss. River Alluvial	Coarse	6	0	0	50	50
	Medium	67	19	33	27	21
			< 160	160-240	240-320	>320
			--------parts per million--------			
	Fine	149	36	38	18	8
	Average*		30	36	21	13
			< 110	110-165	165-220	>220
			--------parts per million--------			
Red River Alluvial	Medium	105	37	50	10	3
			< 160	160-240	240-320	>320
			--------parts per million--------			
	Fine	19	16	37	16	31
	Average*		34	48	11	7
			< 100	100-150	150-200	>200
			--------parts per million--------			
Prairie	Medium	43	70	26	4	0
	Fine	16	63	31	6	0
	Average*		68	27	5	0

(Continued)

Table 60.-(Continued) Summary of soil test results of soil samples from St. Landry Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<55	55-110	110-165	>165
			parts per million			
Miss. Terrace	Medium	663	75	18	4	3
			<60	60-120	120-180	>180
			parts per million			
Miss. River Alluvial	Coarse	6	0	17	17	66
	Medium	67	31	19	14	36
			<80	80-160	160-240	>240
			parts per million			
	Fine	149	64	19	13	4
	Average*		53	19	13	15
			<60	60-120	120-180	>180
			parts per million			
Red R. Alluvial	Medium	105	29	56	11	4
			<80	80-160	160-240	>240
			parts per million			
	Fine	19	58	42	0	0
	Average*		33	54	10	3
			<35	35-70	70-105	>105
			parts per million			
Prairie	Medium	43	63	26	11	0
	Fine	16	63	37	0	0
	Average*		63	29	8	0

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 61.-Summary of soil test results of soil samples from St. Martin Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Medium	103	8	35	27	21	4	5
	Fine	274	7	24	30	27	8	4
	Average*		7	28	29	25	7	4
Miss. Terrace	Medium	51	22	37	27	5	9	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<700	700-1400	1400-2800	>2800
			-------------------parts per million-------------------			
Miss. River Alluvial	Medium	103	21	36	37	6
			<1400	1400-2800	2800-4000	>4000
			-------------------parts per million-------------------			
	Fine	274	6	46	29	19
	Average*		10	44	31	15
			<500	500-1000	1000-2000	>2000
			-------------------parts per million-------------------			
Miss. Terrace	Medium	51	46	36	16	2

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<70	70-140	140-280	>280
			-------------------parts per million-------------------			
Miss. River Alluvial	Medium	103	4	9	22	65
			<140	140-280	280-450	>450
			-------------------parts per million-------------------			
	Fine	274	1	1	12	86
	Average*		2	3	15	80
			<50	50-100	100-200	>200
			-------------------parts per million-------------------			
Miss. Terrace	Medium	51	5	32	34	29

(Continued)

Table 61.-(Continued) Summary of soil test results of soil samples from St. Martin Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 110	110-165	165-220	> 220
			parts per million			
Miss. River Alluvial	Medium	103	46	37	8	9
			< 160	160-240	240-320	> 320
			parts per million			
	Fine	274	44	32	15	9
	Average*		45	33	13	9
			< 100	100-150	150-200	> 200
			parts per million			
Miss. Terrace	Medium	51	41	43	11	5

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 60	60-120	120-180	> 180
			parts per million			
Miss. River Alluvial	Medium	103	77	16	2	5
			< 80	80-160	160-240	> 240
			parts per million			
	Fine	274	84	13	2	1
	Average*		82	14	2	2
			< 55	55-110	110-165	> 165
			parts per million			
Miss. Terrace	Medium	51	86	14	0	0

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 62.-Summary of soil test results of soil samples from St. Mary Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Coarse	3	0	0	67	0	0	33
	Medium	253	5	26	31	24	8	6
	Fine	1120	3	14	28	29	16	10
	Average*		3	16	29	28	14	10
Miss. Terrace	Medium	5	0	60	40	0	0	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 700	700-1400	1400-2800	> 2800
			------------------parts per million------------------			
Miss. River Alluvial	Coarse	3	33	0	0	67
	Medium	253	4	24	64	8
			< 1400	1400-2800	2800-4000	> 4000
			------------------parts per million------------------			
	Fine	1120	5	50	35	10
	Average*		5	45	40	10
			< 500	500-1000	1000-2000	> 2000
			------------------parts per million------------------			
Miss. Terrace	Medium	5	0	20	80	0

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 70	70-140	140-280	> 280
			------------------parts per million------------------			
Miss. River Alluvial	Coarse	3	33	0	0	67
	Medium	253	0	1	16	83
			<140	140-280	280-450	> 450
			------------------parts per million------------------			
	Fine	1120	1	2	17	80
	Average*		1	2	17	80
			< 50	50-100	100-200	> 200
			------------------parts per million------------------			
Miss. Terrace	Medium	5	0	0	20	80

(Continued)

Table 62.-(Continued) Summary of soil test results of soil samples from St. Mary Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			parts per million			
Miss. River Alluvial	Coarse	3	67	0	0	33
	Medium	253	67	26	4	3
			<160	160-240	240-320	>320
			parts per million			
	Fine	1120	67	25	6	2
	Average*		67	25	6	2
			<100	100-150	150-200	>200
			parts per million			
Miss. Terrace	Medium	5	60	0	40	0

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			parts per million			
Miss. River Alluvial	Coarse	3	33	0	0	67
	Medium	253	54	31	8	7
			<80	80-160	160-240	>240
			parts per million			
	Fine	1120	55	29	10	6
	Average*		55	29	10	6
			<55	55-110	110-165	>165
			parts per million			
Miss. Terrace	Medium	5	80	20	0	0

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 63.-Summary of soil test results of soil samples from St. Tammany Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.5	6.5-6.9	>6.9
Flatwoods	Coarse	1083	10	14	24	36	16	0
	Medium	18	22	22	33	6	17	0
	Average*		10	14	24	36	16	0
Coastal Plain	Coarse	48	8	32	30	22	8	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<400	400-800	800-1600	>1600
			parts per million			
Flatwoods	Coarse	1083	24	32	39	5
	Medium	18	44	28	17	11
	Average*		24	32	39	5
			<300	300-500	500-1000	>1000
			parts per million			
Coastal Plain	Coarse	48	24	19	38	19

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<40	40-80	80-160	>160
			parts per million			
Flatwoods	Coarse	1083	3	12	29	56
	Medium	18	0	11	39	50
	Average*		3	12	29	56
			<30	30-50	50-100	>100
			parts per million			
Coastal Plain	Coarse	48	0	0	32	68

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<80	80-120	120-160	>160
			parts per million			
Flatwoods	Coarse	1083	43	30	16	11
	Medium	18	72	22	0	6
	Average*		44	30	15	11
			<80	80-120	120-160	>160
			parts per million			
Coastal Plains	Coarse	48	46	35	14	5

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<35	35-70	70-105	>105
			parts per million			
Flatwoods	Coarse	1083	50	30	9	11
	Medium	18	67	16	11	6
	Average*		51	30	9	10
			<40	40-80	80-120	>120
			parts per million			
Coastal Plain	Coarse	48	46	32	11	11

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 64.-Summary of soil test results of soil samples from Tangipahoa Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Flatwoods	Coarse	2725	13	28	29	24	5	1
	Medium	244	18	22	30	21	8	1
	Average*		13	28	29	24	5	1
Loessial Hills	Coarse	550	13	30	30	21	6	0
	Medium	48	11	29	33	25	2	0
	Average*		13	30	30	21	6	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <400	400-800	800-1600	>1600
			---parts per million---			
Flatwoods	Coarse	2725	31	38	28	3
	Medium	244	20	33	43	4
	Average*		30	38	29	3
			<500	500-1000	1000-2000	>2000
			---parts per million---			
Loessial Hills	Coarse	550	50	38	11	1
	Medium	48	53	36	11	0
	Average*		51	37	11	1

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <40	40-80	80-160	>160
			---parts per million---			
Flatwoods	Coarse	2725	3	19	45	33
	Medium	244	2	11	40	47
	Average*		3	18	45	34
			<50	50-100	100-200	>200
			---parts per million---			
Loessial Hills	Coarse	550	4	32	40	24
	Medium	48	0	25	53	22
	Average*		4	31	41	24

(Continued)

Table 64.-(Continued) Summary of soil test results of soil samples from Tangipahoa Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 80	80-120	120-160	> 160
			parts per million			
Flatwoods	Coarse	2725	34	28	19	19
	Medium	244	37	27	21	15
	Average*		34	28	19	19
			< 100	100-150	150-200	> 200
			parts per million			
Loessial Hills	Coarse	550	45	30	16	9
	Medium	48	51	27	13	9
	Average*		46	29	16	9

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 35	35-70	70-105	> 105
			parts per million			
Flatwoods	Coarse	2725	26	17	9	48
	Medium	244	20	12	10	58
	Average*		26	17	9	48
			< 55	55-110	110-165	> 165
			parts per million			
Loessial Hills	Coarse	550	52	21	8	19
	Medium	48	58	22	7	13
	Average*		53	21	8	18

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 65.-Summary of soil test results of soil samples from Tensas Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Coarse	15	8	0	34	50	0	8
	Medium	185	2	8	45	31	9	5
	Fine	256	0	16	49	28	4	3
	Average*		1	12	47	30	6	4

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <700	700-1400	1400-2800	>2800
			-------parts per million-------			
Miss. River Alluvial	Coarse	15	0	67	33	0
	Medium	185	2	29	63	6
			<1400	1400-2800	2800-4000	>4000
			-------parts per million-------			
	Fine	256	1	38	48	13
	Average*		2	35	53	10

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <70	70-140	140-280	>280
			-------parts per million-------			
Miss. River Alluvial	Coarse	15	0	8	42	50
	Medium	185	0	1	40	59
			<140	140-280	280-450	>450
			-------parts per million-------			
	Fine	256	0	1	17	82
	Average*		0	1	27	72

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <110	110-165	165-220	>220
			-------parts per million-------			
Miss. River Alluvial	Coarse	15	0	17	41	42
	Medium	185	5	27	36	32
			<160	160-240	240-320	>320
			-------parts per million-------			
	Fine	256	4	26	30	40
	Average*		4	26	33	37

(Continued)

Table 65.- (Continued) Summary of soil test results of soil samples from Tensas Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			parts per million			
Miss. River Alluvial	Coarse	15	8	0	42	50
	Medium	185	3	11	32	54
			<80	80-160	160-240	>240
			parts per million			
	Fine	256	26	48	14	12
	Average*		16	31	22	31

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 66.-Summary of soil test results of soil samples from Terrebonne Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Medium	50	0	4	22	29	31	14
	Fine	96	1	3	21	47	21	7
	Average*		1	3	21	40	25	10

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<700	700-1400	1400-2800	>2800
			parts per million			
Miss. River Alluvial	Medium	50	2	2	84	12
			<1400	1400-2800	2800-4000	>4000
			parts per million			
	Fine	96	0	41	42	17
	Average*		1	27	57	15

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<70	70-140	140-280	>280
			parts per million			
Miss. River Alluvial	Medium	50	0	0	8	92
			<140	140-280	280-450	>450
			parts per million			
	Fine	96	0	0	8	92
	Average*		0	0	8	92

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			parts per million			
Miss. River Alluvial	Medium	50	43	47	8	2
			<160	160-240	240-320	>320
			parts per million			
	Fine	96	46	22	20	12
	Average*		45	30	16	9

(Continued)

Table 66.- (Continued) Summary of soil test results of soil samples from Terrebonne Parish. 1964-1967.

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			----------parts per million----------			
Miss. River Alluvial	Medium	50	0	2	8	90
			<80	80-160	160-240	>240
			----------parts per million----------			
	Fine	96	3	18	48	31
	Average*		2	12	34	52

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 67.-Summary of soil test results of soil samples from Union Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	19	5	32	31	21	11	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<300	300-500	500-1000	>1000
			----------parts per million----------			
Coastal Plain	Coarse	19	37	26	26	11

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<30	30-50	50-100	>100
			----------parts per million----------			
Coastal Plain	Coarse	19	11	5	47	37

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<80	80-120	120-160	>160
			----------parts per million----------			
Coastal Plain	Coarse	19	37	21	10	32

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<40	40-80	80-120	>120
			----------parts per million----------			
Coastal Plain	Coarse	19	47	21	11	21

Table 68.-Summary of soil test results of soil samples from Vermilion Parish. 1964-1967.

A. Soil Reaction (pH)

			Percentage of samples testing in the following ranges:					
Soil Area	Soil Texture	No. of Samples	<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Prairie	Coarse	4	0	25	50	0	0	25
	Medium	376	7	32	29	19	11	2
	Fine	147	3	26	31	20	14	6
	Average*		6	30	30	19	12	3
Miss. Terrace	Medium	25	13	50	25	6	6	0

B. Extractable Calcium

			Percentage of samples testing in the following ranges:			
Soil Area	Soil Texture	No. of Samples	<600	600-1200	1200-2400	>2400
			parts per million			
Coastal Prairie	Coarse	4	0	0	25	75
	Medium	376	24	48	23	5
	Fine	147	5	29	43	23
	Average*		18	43	28	11
			<500	500-1000	1000-2000	>2000
			parts per million			
Miss. Terrace	Medium	25	19	69	12	0

C. Extractable Magnesium

			Percentage of samples testing in the following ranges:			
Soil Area	Soil Texture	No. of Samples	<60	60-120	120-240	>240
			parts per million			
Coastal Prairie	Coarse	4	0	0	25	75
	Medium	376	0	3	48	49
	Fine	147	0	0	14	86
	Average*		0	2	39	59
			<50	50-100	100-200	>200
			parts per million			
Miss. Terrace	Medium	25	0	6	38	56

(Continued)

Table 68.-(Continued) Summary of soil test results of soil samples from Vermilion Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <100	100-150	150-200	>200
			----------parts	per million	----------	
Coastal Prairie	Coarse	4	0	0	50	50
	Medium	376	60	23	8	9
	Fine	147	54	24	9	13
	Average*		58	23	9	10
			<100	100-150	150-200	>200
			----------parts	per million	----------	
Miss. Terrace	Medium	25	69	25	0	6

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <35	35-70	70-105	>105
			----------parts	per million	----------	
Coastal Prairie	Coarse	4	75	0	25	0
	Medium	376	72	16	5	7
	Fine	147	66	18	7	9
	Average*		71	16	6	7
			<55	55-110	110-165	>165
			----------parts	per million	----------	
Miss. Terrace	Medium	25	94	6	0	0

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 69.-Summary of soil test results of soil samples from Vernon Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges: <4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	128	12	33	27	19	6	3
Flatwoods	Coarse	4	33	34	33	0	0	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<300	300-500	500-1000	>1000
			------------------parts per million------------------			
Coastal Plain	Coarse	128	41	19	23	17
			<400	400-800	800-1600	>1600
			------------------parts per million------------------			
Flatwoods	Coarse	4	67	33	0	0

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<30	30-50	50-100	>100
			------------------parts per million------------------			
Coastal Plain	Coarse	128	12	15	36	37
			<40	40-80	80-160	>160
			------------------parts per million------------------			
Flatwoods	Coarse	4	0	33	33	34

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<80	80-120	120-160	>160
			------------------parts per million------------------			
Coastal Plain	Coarse	128	46	30	12	12
Flatwoods	Coarse	4	67	33	0	0

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<40	40-80	80-120	>120
			------------------parts per million------------------			
Coastal Plain	Coarse	128	48	27	9	16
			<35	35-70	70-105	>105
			------------------parts per million------------------			
Flatwoods	Coarse	4	67	0	33	0

Table 70.-Summary of soil test results of soil samples from Washington Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	1004	6	19	30	32	11	2
Flatwoods	Coarse	22	9	9	27	23	27	5
Loessial Hills	Medium	9	40	0	20	40	0	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 300	300-500	500-1000	>1000
			parts per million			
Coastal Plain	Coarse	1004	25	27	35	13
			< 400	400-800	800-1600	>1600
			parts per million			
Flatwoods	Coarse	22	45	18	32	5
			<500	500-1000	1000-2000	>2000
			parts per million			
Loessial Hills	Medium	9	60	40	0	0

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 30	30-50	50-100	>100
			parts per million			
Coastal Plain	Coarse	1004	2	5	29	64
			< 40	40-80	80-160	>160
			parts per million			
Flatwoods	Coarse	22	5	9	45	41
			< 50	50-100	100-200	>200
			parts per million			
Loessial Hills	Medium	9	20	20	60	0

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 80	80-120	120-160	>160
			parts per million			
Coastal Plain	Coarse	1004	42	30	16	12
Flatwoods	Coarse	22	27	27	23	23
			<100	100-150	150-200	>200
			parts per million			
Loessial Hills	Medium	9	60	20	20	0

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 40	40-80	80-120	>120
			parts per million			
Coastal Plain	Coarse	1004	45	31	14	10
			< 35	35-70	70-105	>105
			parts per million			
Flatwoods	Coarse	22	45	18	23	14
			< 55	55-110	110-165	>165
			parts per million			
Loessial Hills	Medium	9	60	40	0	0

Table 71.-Summary of soil test results of soil samples from Webster Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	4	0	50	0	50	0	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<300	300-500	500-1000	>1000
			------------------parts per million------------------			
Coastal Plain	Coarse	4	25	50	25	0

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<30	30-50	50-100	>100
			------------------parts per million------------------			
Coastal Plain	Coarse	4	0	0	75	25

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<80	80-120	120-160	>160
			------------------parts per million------------------			
Coastal Plain	Coarse	4	25	50	25	0

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<40	40-80	80-120	>120
			------------------parts per million------------------			
Coastal Plain	Coarse	4	75	25	0	0

Table 72.-Summary of soil test results of soil samples from West Baton Rouge Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. River Alluvial	Coarse	2	0	0	0	0	100	0
	Medium	31	0	0	14	24	21	41
	Fine	98	0	0	21	45	25	9
	Average*		0	0	19	38	26	17

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<700	700-1400	1400-2800	>2800
			parts per million			
Miss. River Alluvial	Coarse	2	0	0	100	0
	Medium	31	7	7	72	14
			<1400	1400-2800	2800-4000	>4000
			parts per million			
	Fine	98	0	55	40	5
	Average*		2	43	48	7

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<70	70-140	140-280	>280
			parts per million			
Miss. River Alluvial	Coarse	2	0	0	0	100
	Medium	31	0	7	3	90
			<140	140-280	280-450	>450
			parts per million			
	Fine	98	0	1	9	90
	Average*		0	2	8	90

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<110	110-165	165-220	>220
			parts per million			
Miss. River Alluvial	Coarse	2	100	0	0	0
	Medium	31	21	48	17	14
			<160	160-240	240-320	>320
			parts per million			
	Fine	98	33	38	20	9
	Average*		31	40	19	10

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<60	60-120	120-180	>180
			parts per million			
Miss. River Alluvial	Coarse	2	0	0	0	100
	Medium	31	10	0	17	73
			<80	80-160	160-240	>240
			parts per million			
	Fine	98	2	21	49	28
	Average*		4	16	40	40

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 73.-Summary of soil test results of soil samples from West Carroll Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Miss. Terrace	Medium	1223	9	29	26	21	11	4
Miss. River Alluvial	Medium	20	15	25	25	25	0	10
	Fine	140	0	5	39	36	17	3
	Average*		2	8	37	34	15	4
Ouachita River Alluvial	Medium	3	0	75	0	0	25	0
	Fine	8	0	13	75	12	0	0
	Average*		0	27	55	9	9	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 500	500-100	100-2000	>2000
			--------parts	per	million--------	
Miss. Terrace	Medium	1223	26	47	22	5
			<700	700-1400	1400-2800	> 2800
			--------parts	per	million--------	
Miss. River Alluvial	Medium	20	15	20	45	20
			<1400	1400-2800	2800-4000	>4000
			--------parts	per	million--------	
	Fine	140	0	36	34	30
	Average*		2	33	35	30
			<700	700-1400	1400-2800	>2800
			--------parts	per	million--------	
Ouachita River Alluvial	Medium	3	0	75	25	0
			<1400	1400-2800	2800-4000	>4000
			--------parts	per	million--------	
	Fine	8	12	13	75	0
	Average*		9	27	64	0

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<50	50-100	100-200	>200
			--------parts	per	million--------	
Miss. Terrace	Medium	1223	0	6	43	51
			<70	70-140	140-280	>280
			--------parts	per	million--------	
Miss. River Alluvial	Medium	20	0	10	15	75
			<140	140-280	280-450	>450
			--------parts	per	million--------	
	Fine	140	0	0	16	84
	Average*		0	1	16	83
			<70	70-140	140-280	>280
			--------parts	per	million--------	
Ouachita River Alluvial	Medium	3	0	0	25	75
			<140	140-280	280-450	>450
			--------parts	per	million--------	
	Fine	8	0	0	0	100
	Average*		0	0	9	91

(Continued)

Table 73.- (Continued) Summary of soil test results of soil samples from West Carroll Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<100	100-150	150-200	>200
			parts per million			
Miss. Terrace	Medium	1223	25	39	21	15
			<110	110-165	165-220	>220
			parts per million			
Miss. River Alluvial	Medium	20	0	30	40	30
			<160	160-240	240-320	>320
			parts per million			
	Fine	140	10	33	18	39
	Average*		9	33	20	38
			<110	110-165	165-220	>220
			parts per million			
Ouachita River Alluvial	Medium	3	0	0	33	67
			<160	160-240	240-320	>320
			parts per million			
	Fine	8	25	13	25	37
	Average*		18	9	28	45

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<55	55-110	110-165	>165
			parts per million			
Miss. Terrace	Medium	1223	48	37	9	6
			<60	60-120	120-180	>180
			parts per million			
Miss. River Alluvial	Medium	20	30	55	0	15
			<80	80-160	160-240	>240
			parts per million			
	Fine	140	34	42	22	2
	Average*		34	43	19	4
			<60	60-120	120-180	>180
			parts per million			
Ouachita River Alluvial	Medium	3	75	0	0	25
			<80	80-160	160-240	>240
			parts per million			
	Fine	8	100	0	0	0
	Average*		90	0	0	10

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 74.-Summary of soil test results of soil samples from West Feliciana Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			< 4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	> 6.9
Loessial Hills	Coarse	16	7	20	40	20	13	0
	Medium	320	5	19	30	27	16	3
	Average*		5	19	31	26	16	3
Miss. River Alluvial	Medium	33	0	0	0	0	0	100
	Fine	22	0	0	9	5	0	86
	Average*		0	0	4	2	0	94

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 500	500-1000	1000-2000	> 2000
			parts per million			
Loessial Hills	Coarse	16	13	73	7	7
	Medium	320	25	55	18	2
	Average*		24	56	18	2
			< 700	700-1400	1400-2800	> 2800
			parts per million			
Miss. River Alluvial	Medium	33	0	0	3	97
			< 1400	1400-2800	2800-4000	> 4000
			parts per million			
	Fine	22	5	14	31	50
	Average*		2	5	15	78

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 50	50-100	100-200	> 200
			parts per million			
Loessial Hills	Coarse	16	0	0	60	40
	Medium	320	0	5	47	48
	Average*		0	5	47	48
			< 70	70-140	140-280	> 280
			parts per million			
Miss. River Alluvial	Medium	33	0	0	0	100
			< 140	140-280	280-450	> 450
			parts per million			
	Fine	22	0	5	5	90
	Average*		0	2	2	96

(Continued)

Table 74.-(Continued) Summary of soil test results of soil samples from West Feliciana Parish. 1964-1967.

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 100	100-150	150-200	> 200
			------parts per million------			
Loessial Hills	Coarse	16	47	20	20	13
	Medium	320	25	37	20	18
	Average*		26	36	20	18
			< 110	110-165	165-220	> 220
			------parts per million------			
Miss. River Alluvial	Medium	33	0	33	40	27
			< 160	160-240	240-320	> 320
			------parts per million------			
	Fine	22	5	9	50	36
	Average*		2	24	43	31

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			< 55	55-110	110-165	> 165
			------parts per million------			
Loessial Hills	Coarse	16	47	33	0	20
	Medium	320	73	20	4	3
	Average*		71	21	4	4
			< 60	60-120	120-180	> 180
			------parts per million------			
Miss. River Alluvial	Medium	33	0	0	36	64
			< 80	80-160	160-240	> 240
			------parts per million------			
	Fine	22	5	0	27	68
	Average*		2	0	33	65

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

Table 75.-Summary of soil test results of soil samples from Winn Parish. 1964-1967.

A. Soil Reaction (pH)

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:					
			<4.9	5.0-5.4	5.5-5.9	6.0-6.4	6.5-6.9	>6.9
Coastal Plain	Coarse	116	10	17	29	26	18	0
Red River Alluvial	Medium	7	0	0	60	40	0	0

B. Extractable Calcium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<300	300-500	500-1000	>1000
			--------------------parts per million------------------			
Coastal Plain	Coarse	116	33	39	20	8
			<700	700-1400	1400-2800	>2800
			--------------------parts per million------------------			
Red River Alluvial	Medium	7	40	60	0	0

C. Extractable Magnesium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<30	30-50	50-100	>100
			--------------------parts per million------------------			
Coastal Plain	Coarse	116	9	7	41	43
			<70	70-140	140-280	>280
			--------------------parts per million------------------			
Red River Alluvial	Medium	7	0	0	60	40

D. Extractable Potassium

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<80	80-120	120-160	>160
			--------------------parts per million------------------			
Coastal Plain	Coarse	116	54	30	7	9
			<110	110-165	165-220	>220
			--------------------parts per million------------------			
Red River Alluvial	Medium	7	40	20	40	0

E. Extractable Phosphorus

Soil Area	Soil Texture	No. of Samples	Percentage of samples testing in the following ranges:			
			<40	40-80	80-120	>120
			--------------------parts per million------------------			
Coastal Plain	Coarse	116	74	20	4	2
			<60	60-120	120-180	>180
			--------------------parts per million------------------			
Red River Alluvial	Medium	7	40	60	0	0

*Weighted average based on frequency distribution of the number of soil samples occurring in each range for all textural classes.

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The Soils of St. Mary Parish, Louisiana

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The Soils of St. Mary Parish, Louisiana

S. A. Lytle and B. N. Driskell[1]

Introduction

The purpose of this report is to present information about the properties of the soils of St. Mary Parish that may be of value to users of the soils. A thorough knowledge of the physical, chemical and mineralogical properties of the soils is essential if the soils are to be used and managed properly and profitably. From the data presented here interpretations can be made about the behavior of the soils under different uses, and about the kind and degree of management or manipulation that is needed when the soils are used for farming or for engineering or other purposes. A knowledge of the properties of the "wet lands" at different locations will be helpful in selecting areas suitable for reclamation.

The data included in this report are from a study of soil samples from 97 sites in St. Mary Parish. The information presented is supplemental to that of the soil survey report of St. Mary Parish which was published in 1959 as a cooperative project of the Louisiana Agricultural Experiment Station and the USDA, Soil Conservation Service.

Nature of the Area

St. Mary Parish, with a total land area of 387,200 acres, lies along the northern shore of the Gulf of Mexico. It has fertile soils, a warm, humid, subtropical climate and a long growing season. Only about 28 per cent of the parish is used for farming; this is the area of natural-levee ridges associated with the present streams and former stream channels. Approximately 72 per cent of the parish is included in the "wet lands," or the coastal marshlands and associated swamps that lie adjacent to the shore of the Gulf and border the drier cultivated soils. The wet lands are inundated by shallow water for several months each year, or they have a water table at or near the soil surface most of the time. These soils are too wet for farming without intensive drainage.

Properties of the Soils Used for Farming

The soils used for farming have developed in silty and clayey sediments representing the natural-levee ridges of older deltas and parts of older deltas of the Mississippi River mixed with some Red River sediments. The silty sediments contain some fine sand and very fine sand. The natural-levee ridges have a maximum elevation of 16 feet in the northwestern part of the parish. The ridges become progressively lower in elevation toward the south and southwest, where they extend into and beneath the coastal marshlands. In most places, the natural-levee ridges lie above 5 feet in elevation, and the soils are drained by the gravity flow of the excess water.

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[1] Associate Professor and former Associate Professor, Department of Agronomy, Louisiana Agricultural Experiment Station, Baton Rouge.

The brown, moderately well-drained Cypremort soils and the grayish brown, somewhat poorly drained Patoutville soils typically occupy level and gently sloping areas at the higher elevations on the crests of the natural levees. The dark grayish brown, somewhat poorly drained Baldwin soils occupy nearly level slopes that typically lie along the border of the Cypremort soils at elevations 1 to 3 feet lower than the Cypremort soils. The silty, black Jeanerette soils and the clayey, black Iberia soils occupy flats and embayments along the lower borders of the natural levees at elevations of 3 to 5 feet above sea level. The gray, clayey, poorly drained Alligator soils occupy depressions and flat areas along the backswamp streams. Most areas of Cypremort, Baldwin and Jeanerette soils are drained by row direction and open ditches. Some cultivated areas of Iberia and Alligator soils are protected from flooding by dykes and are drained by pumps.

Two soils in St. Mary Parish which are not included in this study are the brown, silty, well-drained Memphis (Lintonia) soil and the brown, silty, moderately well-drained Loring (Richland) soil. These soils occur in small areas as the capping materials over the two salt domes having surface expression in this parish. These salt domes are Belle Isle, with an elevation of 80 feet, and Cote Blanche Island, with an elevation of more than 100 feet.

The usual crops are sugarcane, soybeans, corn and rice. The largest acreage of farmed land is used for sugarcane.

In the following section, 26 profiles of soils that are used for farming are located and described. The data show the results of chemical analyses on each of the soil profiles. In addition, clay mineralogical data are shown for 12 selected soil profiles. Each soil profile site is located by a number on the Soil Associations map on pages 46-47. Definitions of the symbols used for soil horizons are presented on page 91 of this report.

Soil Profile No. 10. ALLIGATOR CLAY

Sampled from a level sugarcane field, along Bayou Yokley 1½ miles south of Columbia sugar mill; elevation 3 feet; Sec. 12, T. 14 S., R. 9 E., St. Mary Parish.

Ap_1[1]	0-2"	Dark gray (10YR 4/1)[2] clay; fine angular blocky structure; very firm moist; pH 6.5.[3]
Ap_2	2-10"	Gray (10YR 5/1) clay mottled with very dark grayish brown (10YR 3/2); coarse platy structure; very firm moist; pH 5.8.
C_{1g}	10-16"	Gray (10YR 5/1) clay mottled 20 per cent with dark brown (10YR 3/3); numerous dark brown coatings of oxidized soil material around roots and in root channels; massive to weak blocky structure; very firm moist; pH 5.5.
C_{2g}	16-42"	Gray (10YR 6/1) clay mottled 20 per cent with dark brown; massive; plastic wet; pH 5.7.

Chemical Characteristics

Soil Hori-zon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P[4] ppm	Extractable Bases[5] Ca	Mg	K	Na	Ext. Acid-ity	CEC	Base Sat. %
							--------meq/100g					--------	
Ap_1	0-2	6.1	7.3	.30	10.7	149	24.0	15.3	.7	.6	5.7	46	88
Ap_2	2-10	5.9	1.2	.07	9.8	149	21.4	13.0	.4	.6	5.6	41	86
C_{1g}	10-16	5.6	2.5			39	14.9	11.5	.4	.9	7.3	35	79
C_{2g}	16-42	6.0	0.8				16.7	14.1	.9	.9	5.1	37	86

Mineralogical Characteristics of the < 2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmor-illonite %	Illite %	Kaolinite %	Quartz %
Ap_1	0-2	46	> 40	10-40	10-40	< 10

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[1] Definitions of soil horizon symbols in back of the report.
[2] Colors by Munsell color notations for moist soils.
[3] pH by Hellige-Truog field test kit.
[4] 0.1N HCl extractable P.
[5] Bases extracted with ammonium acetate at pH 7.0. Extractable acidity by barium acetate displacement and titration with base.

Soil Profile No. 11. ALLIGATOR CLAY

Sampled from a level field of sugarcane; 1¼ miles southwest of Columbia sugar mill; Sec. 13, T. 14 S., R. 9 E., St. Mary Parish. Elevation 3 to 4 feet. Runoff very slow.

Ap$_1$	0-4"	Very dark gray (10YR 3/1) clay; fine angular blocky structure; plastic wet; pH 5.8.
Ap$_2$	4-6"	Dark gray (10YR 5/2) clay mottled with gray (10YR 6/1); platy structure; plastic wet; pH 5.5.
Ap$_3$	6-10"	Dark gray (10YR 4/1) clay with common coarse prominent mottles and root coatings of dark reddish-brown; coarse platy structure; plastic wet; pH 6.0.
Cg	10-42"	Gray (10YR 5/1) clay with fine distinct mottles of dark yellowish-brown; massive to weak angular blocky structure; plastic wet; pH 7.0 to 7.5.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acidity	CEC	Base Sat. %
							meq/100g						
Ap$_1$	0-4	5.7	2.7	.16	10.0	46	22.8	17.5	1.4	.6	5.8	48.2	88
Ap$_2$	4-6	5.8	3.0	.16	10.7	51	24.4	18.1	1.2	.6	4.9	49.2	90
Ap$_3$	6-10	5.9	3.0				24.9	18.5	1.1	.6	5.3	50.4	86
Cg	10-42	6.8	1.2				28.4	17.7	1.0	.7	1.8	49.2	96

Mineralogical characteristics of the < 2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmorillonite %	Illite %	Kaolinite %	Quartz %
Ap$_1$	0-4	48	> 40	10-40	10-40	< 10
Ap$_2$	4-6	49	> 40	10-40	10-40	< 10
Ap$_3$	6-10	50	> 40	10-40	10-40	< 10
Cg	10-42	49	> 40	10-40	10-40	< 10

Soil Profile No. 12. BUXIN SILTY CLAY LOAM

Sampled from a sloping field of sugarcane (2 per cent slope) along the northern side of Bayou Teche; ½ mile northeast of Columbia store on Katy Plantation; Sec. 48, T. 14 S., R. 9 E., St. Mary Parish.

Ap	0-4"	Dark brown (7.5YR 4/4) silty clay loam; fine granular structure; slightly plastic wet; pH 6.0.
II C_1	4-10"	Red (2.5YR 4/6) clay; weak to moderate fine blocky structure; very firm moist; few small black concretions; pH 7.0.
II C_2	10-18"	Reddish-brown (5YR 4/4) clay mottled red (2.5YR 4/6); strong medium subangular blocky structure; very firm moist; a few small black concretions; pH 8.0.
II C_3	18-30"	Reddish-brown (5YR 4/4) clay, mottled with light brownish-gray (10YR 6/2); strong medium subangular blocky structure; plastic wet; numerous small black concretions; pH 8.0.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acidity	CEC	Base Sat. %
							meq/100g						
Ap	0-4	6.6	1.10	.07	8.9	86	12.2	9.3	.6	.6	2.1	24.8	92
II C_1	4-10	7.3	0.48			86	15.9	15.6	.7	1.7	1.0	34.9	97
II C_2	10-18	7.5	0.48				15.3	14.7	.7	2.1	0.8	33.6	98
II C_3	18-30	7.9	0.43				17.5	17.0	.9	3.1	0.5	38.9	99

Soil Profile No. 13. BUXIN SILTY CLAY LOAM

Sampled from a field used for sugarcane, having a slope of 2 per cent; along Bayou Teche; ½ mile south of the headquarters of Oxford Plantation; Sec. 42, T. 14 S., R. 10 E., St. Mary Parish.

Ap_1	0-6"	Very dark gray (10YR 3/1) heavy silty clay loam; fine granular structure; friable; pH 6.0.
Ap_2	6-12"	Very dark gray (10YR 3/1) silty clay with a few mottles of pale brown (10YR 6/3) and light brownish-gray (10YR 6/2); coarse platy structure; firm moist; pH 6.5.
A-C	12-16"	Very dark gray (10YR 3/1) clay mottled brown (10YR 5/3) and yellowish-red (5YR 5/4); medium subangular blocky structure; plastic wet; pH 7.5.
C_1	16-24"	Pale brown (10YR 6/3) clay mottled dark gray (10YR 4/1) and reddish-brown (5YR 5/3); weak subangular blocky structure; plastic wet; pH 7.5.
C_2	24-32"	Mottled gray (10YR 5/1) dark gray (10YR 4/1) and pale brown (10YR 6/3) silty clay; massive; very firm moist; pH 7.5.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acidity	CEC	Base Sat. %
							---------	------	meq/100g	------	------	---------	
Ap_1	0-6	6.1	3.30	.15	13.4	3	14.0	8.2	.5	.2	5.2	28.1	81
Ap_2	6-12	6.7	2.80	.12	13.1	1	16.7	9.4	.4	.3	2.4	29.2	92
A-C	12-16	7.5	1.00	.07	9.1		17.3	9.7	.5	.3		27.9	100
C_1	16-24	7.6	.76	.05	9.2		14.8	8.2	.4	.3		23.8	100
C_2	24-32	7.5	.57	.04	8.9		11.2	7.0	.4	.3		18.8	100

(Continued)

Soil Profile No. 13. BUXIN SILTY CLAY LOAM (Continued)

Chemical Composition of the Soil

	Ap1 0-6	Ap_2 6-12	A-C 12-16	C_1 16-24	C_2 24-32
	Per cent				
SiO_2	71.74	70.84	68.25	71.22	75.84
TiO_2	00.61	00.58	00.57	00.56	00.53
Al_2O_3	12.59	13.58	14.88	13.57	12.39
Fe_2O_3	4.16	4.50	5.53	4.92	3.70
MnO	00.06	00.06	00.10	00.10	00.06
CaO	00.68	00.76	00.80	00.70	00.69
MgO	1.35	1.56	1.93	1.74	1.48
K_2O	1.85	1.85	2.14	2.08	2.03
Na_2O	1.37	1.53	1.47	1.68	1.70
P_2O_5	00.12	00.11	00.09	00.10	00.11
Ignition Loss	4.96	4.10	3.70	2.57	1.68
Total	99.49	99.47	99.46	99.74	100.21

Chemical Composition of the < 2 Microns Clay

	Ap_1 0-6	Ap_2 6-12	A-C 12-16	C_1 16-24	C_2 24-32
	Per cent				
SiO_2	49.82	49.87	51.62	52.18	52.72
TiO_2	00.70	00.71	00.82	00.82	00.78
Al_2O_3	22.67	23.03	23.91	24.06	24.13
Fe_2O_3	7.13	7.02	7.33	7.38	7.34
MnO	00.11	00.09	00.07	00.06	00.07
CaO	1.24	1.34	1.23	1.21	1.20
MgO	2.74	2.85	3.24	3.25	3.28
K_2O	1.50	1.87	1.86	1.99	1.94
Na_2O	00.37	00.39	00.36	00.37	00.47
P_2O_5	00.22	00.16	00.17	00.19	00.12
Ignition Loss	13.56	12.83	9.43	9.16	9.35
Total	100.06	100.15	100.04	100.66	100.89

Soil Profile No. 14. BUXIN SILTY CLAY

Sampled from a sugarcane field having a slope of 2 to 3 per cent, located 1¼ miles west of Columbia Store, Katy Plantation; Sec. 46, T. 14 S., R. 9 E., St. Mary Parish.

Ap_1	0-7"	Reddish-brown (5YR 4/4) silty clay; fine angular blocky structure; firm moist; pH. 6.0.
Ap_2	7-10"	Olive brown (2.5Y 4/4) clay mottled reddish-brown (5YR 5/3) and yellowish-red (5YR 5/6); massive to weak platy structure; very firm moist; few small black concretions; pH 6.5.
C_1	10-18"	Yellowish-brown (10YR 5/4) clay mottled with strong brown (7.5YR 5/6); moderate medium angular blocky structure; plastic wet; few brown concretions; pH 7.0.
IIC_2	18-34"	Light brownish-gray (10YR 6/2) very fine sandy loam mottled pale brown (10YR 6/3) and yellowish brown (10YR 5/8); massive; friable; pH 8.0.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acidity	CEC	Base Sat. %
							meq/100g						
Ap_1	0-7	5.9	1.20	.07	9.1	23	12.5	10.1	.8	.4	3.00	26.8	89
Ap_2	7-10	6.4	0.71	.06	7.4	23	13.1	12.7	.7	.7	2.00	29.2	93
C_1	10-18	6.8	0.51	.04	7.1		11.6	11.2	.6	.8	1.20	25.4	95
IIC_2	18-34	7.6	0.35	.03	7.2		9.0	8.2	.4	.9	0.22	18.6	99

Mineralogical Characteristics of the < 2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmorillonite %	Illite %	Kaolinite %	Quartz %
Ap_1	0-7	27	>40	10-40	10-40	<10
Ap_2	7-10	29	>40	10-40	10-40	<10
C_1	10-18	25	>40	10-40	10-40	<10
IIC_2	18-34	19	>40	10-40	10-40	<10

(Continued)

Soil Profile No. 14. BUXIN SILTY CLAY (Continued)

Chemical Composition of the Soil

	Ap_1 0-7	Ap_2 7-10	C_1 10-18	IIC_2 18-34
		Per cent		
SiO_2	68.06	65.70	68.75	76.00
TiO_2	00.65	00.64	00.65	00.48
Al_2O_3	15.83	17.66	15.78	12.12
Fe_2O_3	5.52	6.06	5.31	3.52
MnO	00.09	00.09	00.08	00.05
CaO	00.61	00.66	00.72	00.70
MgO	2.02	2.19	2.36	1.37
K_2O	2.05	2.09	2.19	1.86
Na_2O	1.51	1.51	1.63	1.95
P_2O_5	00.12	00.13	00.15	00.14
Ignition Loss	3.21	3.24	2.20	1.43
Total	99.67	99.97	99.82	99.68

Chemical Composition of the < 2 Microns Clay

	Ap_1 0-7	Ap_2 7-10	C_1 10-18	IIC_2 18-34
		Per cent		
SiO_2	51.48	51.88	52.31	53.16
TiO_2	00.66	00.72	00.67	00.59
Al_2O_3	23.65	23.48	23.48	22.54
Fe_2O_3	8.47	8.50	8.67	8.62
MnO	00.13	00.14	00.14	00.06
CaO	00.76	00.80	00.87	1.10
MgO	3.37	3.65	3.62	3.20
K_2O	2.27	2.30	2.20	2.10
Na_2O	00.22	00.23	00.24	00.22
P_2O_5	00.21	00.18	00.18	00.21
Ignition Loss	9.09	8.73	8.48	8.54
Total	100.31	100.61	100.86	100.34

Soil Profile No. 15. BALDWIN VERY FINE SANDY LOAM

Soil samples from a level field planted to sugarcane, corn, and soybeans located 5/8 mile north of Columbia sugar mill on Katy Plantation; Sec. 48, T. 14 S., R. 9 E., St. Mary Parish.

Ap	0-7	Dark grayish-brown (10YR 4/2) very fine sandy loam; granular structure; friable; pH 6.5.
B$_{2t}$	7-17"	Light brownish-gray (10YR 6/2) clay, mottled with pale brown (10YR 6/3), dark gray (10YR 4/1) and gray (10YR 5/1); strong medium subangular blocky structure; some dark gray clay skins on horizontal and vertical ped faces; very firm moist; pH 7.5.
C	17-30"	Pale brown (10YR 6/3) very fine sandy loam mottled with gray (10YR 6/1) and brownish-yellow (10YR 6/6); massive; friable; pH 7.0.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acidity	CEC	Base Sat. %
							meq/100g						
Ap	0-7	6.8	1.60	.08	11.4	4	9.6	4.0	.2	.2	1.6	15.6	90
B$_{2t}$	7-17	7.0	0.97	.07	8.4	7	15.4	8.7	.5	.5	1.4	26.4	95
C	17-30	7.2	0.46	.04	7.1		10.7	7.5	.4	.5	1.0	20.1	95

(Continued)

Soil Profile No. 15. BALDWIN VERY FINE SANDY LOAM (Continued)

Chemical Composition of the Soil

	Ap 0-7	B_{2t} 7-17	C 17-30
	Per cent		
SiO_2	79.29	71.24	74.43
TiO_2	00.28	00.53	00.62
Al_2O_3	10.55	15.91	12.49
Fe_2O_3	2.17	3.53	4.52
MnO	00.03	00.05	00.06
CaO	00.65	00.54	00.59
MgO	1.16	1.23	1.07
K_2O	1.71	1.81	1.87
Na_2O	1.68	1.53	1.64
P_2O_5	00.03	00.08	00.07
Ignition Loss	3.32	3.92	3.12
Total	100.87	100.37	100.48

Mineralogical Characteristics of the < 2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmorillonite %	Illite %	Kaolinite %	Quartz %
Ap	0-7	15.6	10-40	10-40	10-40	< 10
B_{2t}	7-17	26.4	10-40	10-40	10-40	< 10
C	17-30	20.1	10-40	10-40	< 10	< 10

Soil Profile No. 16. BALDWIN SILT LOAM

Sampled from a level field planted to sugarcane, ½ mile southeast of Columbia Store, Katy Plantation, Sec. 11, T. 14 S., R. 9 E., St. Mary Parish.

Ap$_1$	0-6"	Very dark grayish-brown (10YR 3/2) silt loam; strong medium granular structure; friable; pH 6.0.
Ap$_2$	6-9"	Dark gray (10YR 4/1) clay mottled yellowish-brown (10YR 5/6); strong coarse platy structure; pH 6.0.
B$_{2t}$	9-24"	Dark gray (10YR 4/1) clay mottled yellowish-brown (10YR 5/4-5/6); moderate medium subangular blocky structure; few black clay skins on ped faces; plastic wet; pH 6.0.
C	24-30"	Light brownish-gray (10YR 6/2) silty clay loam mottled light gray (10YR 7/1) and yellowish-brown (10YR 5/6); massive; slightly plastic wet; pH 7.0.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases				Ext. Acidity	CEC	Base Sat. %
							Ca	Mg	K	Na			
							meq/100g						
Ap$_1$	0-6	6.5	2.30	.12	11.2	15	12.6	6.0	.4	.2	1.4	20.6	93
Ap$_2$	6-9	6.1	1.90	.10	11.0		16.8	5.9	.6	.6	5.3	32.7	84
B2t	9-24	6.4	1.20	.07	9.8		17.2	10.7	.6	.8	4.9	34.3	84
C	24-30	6.9	0.57	.05	7.1		14.8	10.8	.5	1.1	1.6	28.8	94

(Continued)

Soil Profile No. 16. BALDWIN SILT LOAM (Continued)

Chemical Composition of the Soil

	Ap_1 0-6	Ap_2 6-9	B_{2t} 9-24	C 24-30
	Per cent			
SiO_2	75.26	70.07	68.05	70.33
TiO_2	00.59	00.62	00.69	00.68
Al_2O_3	11.62	16.01	16.57	15.10
Fe_2O_3	3.98	4.05	4.53	4.40
MnO	00.08	00.04	00.07	00.13
CaO	00.70	00.66	00.69	00.76
MgO	1.08	1.09	1.32	1.41
K_2O	1.80	1.82	1.90	1.98
Na_2O	1.49	1.26	1.37	1.68
P_2O_5	00.08	00.09	00.11	00.11
Ignition Loss	4.25	4.53	5.45	4.06
Total	100.68	100.24	100.75	100.64

Mineralogical Characteristics of the < 2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmorillonite %	Illite %	Kaolinite %	Quartz %
Ap_1	0-6	20.6	>40	10-40	10-40	< 10
Ap_2	6-9	23.7	>40	10-40	10-40	< 10
B_{2t}	9-24	34.3	>40	10-40	10-40	< 10
C	24-30	28.8	>40	10-40	10-40	< 10

Soil Profile No. 17. BALDWIN SILT LOAM

Sampled from a level cultivated field of sugarcane and corn located 1½ mile southwest of Columbia sugar mill; Sec. 13, T. 14 S., R. 9 E., St. Mary Parish. Elevation 8 to 10 feet.

Ap_1	0-7"	Very dark grayish-brown (10YR 3/2) silt loam; fine granular structure; friable; pH 6.0.
Ap_2	7-10"	Very dark grayish-brown (10YR 3/2) silt loam; moderate coarse platy structure; firm moist; pH 6.5.
Ap_3	10-12"	Very dark gray (10YR 3/1) clay; moderate coarse platy structure; very firm moist; pH 6.5.
B_{21t}	12-18"	Dark gray (10YR 4/1) clay, mottled with light yellowish-brown (10YR 6/4); strong medium angular blocky structure; patchy dark gray clay skins on ped faces; very firm moist; pH 7.0.
B_{22t}	18-32"	Mottled gray (10YR 5/1) and pale brown (10YR 6/3) silty clay; strong medium angular blocky structure; few dark gray clay skins on ped faces; very firm moist; pH 7.5.
C	32-44"	Light brownish-gray (10YR 6/2) silty clay loam, mottled dark brown (7.5YR 4/4) and dark gray (10YR 4/1); weak medium angular blocky structure; slightly plastic wet; pH 7.5.

Chemical Characteristics

Soil Hori- zon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acid- ity	CEC	Base Sat. %
							----------	----------	----------	meq/100g	----------	----------	
Ap_1	0-7	5.9	2.10			84	10.6	3.3	.1	.3	3.6	17.9	80
Ap_2	7-10	6.1	2.20			47	12.5	4.2	.1	.2	3.4	20.4	83
Ap_3	10-12	6.4	2.30			6	18.2	7.1	.3	.4	3.6	29.5	88
B_{21t}	12-18	6.6	1.60			9	18.4	8.3	.2	.4	3.9	31.2	88
B_{22t}	18-32	6.9	0.69			72	17.2	8.4	.3	.6	1.5	27.9	95
C	32-44	6.8	0.58			53	16.7	9.6	.3	.7	1.4	28.7	95

(Continued)

Soil Profile No. 17. BALDWIN SILT LOAM (Continued)

Chemical Composition of the Soil

	Ap_1 0-7	Ap_2 7-10	Ap_3 10-12	B_{21t} 12-18	B_{22t} 18-32	C 32-44
	Per cent					
SiO_2	79.80	77.48	71.79	71.03	70.65	70.48
TiO_2	00.83	00.85	00.89	00.89	00.86	00.89
Al_2O_3	10.22	10.85	13.71	14.53	15.06	14.95
Fe_2O_3	1.55	1.94	3.09	3.53	3.69	3.87
MnO	00.06	00.05	00.06	00.06	00.10	00.13
CaO	00.55	00.60	00.74	00.75	00.75	00.74
MgO	00.63	00.69	1.03	1.15	1.35	1.38
K_2O	1.81	1.90	1.93	1.96	2.18	2.28
Na_2O	1.76	1.62	1.63	1.64	1.66	1.66
P_2O_5	00.32	00.21	00.14	00.10	00.22	00.24
Ignition Loss	3.99	4.25	5.68	5.31	4.38	4.14
Total	100.62	100.44	100.69	100.95	100.90	100.76

Soil Profile No. 18. BALDWIN SILT LOAM, SALTY VARIANT

Sampled from a level field of sugarcane in reclaimed brackish marsh area; 6/10 mile southwest of Ivanhoe Plantation headquarters; center of the north border of T. 15 S., R. 7 E., St. Mary Parish.

Ap$_1$	0-6"	Very dark grayish-brown (10YR 3/2) silt loam; granular structure; moderately firm moist; pH 6.0.
Ap$_2$	6-14"	Very dark gray (10YR 3/1) silt loam; strong thin platy structure; firm; pH 6.5.
A-C	14-22"	Black (10YR 2/1) silty clay loam mottled with very dark grayish-brown (10YR 3/2); massive; friable; pH 7.0.
C$_1$	22-30"	Dark grayish-brown (2.5Y 4/2) silty clay loam mottled with very dark gray (10YR 3/1) massive; friable; pH 7.5.
C$_2$	30-38"	Dark grayish-brown (2.5Y 4/2) silty clay mottled with olive brown (2.5Y 4/4); massive; plastic wet; contains many small black and brown concretions; pH 7.5.
C$_3$	38-42"	Dark gray (5Y 4/1) very fine sandy loam mottled with olive gray (5Y 5/2); massive; friable; few small brown and black concretions; pH 7.5.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases				Ext. Acidity	CEC	Base Sat. %
							Ca	Mg	K	Na			
							meq/100g						
Ap$_1$	0-6	7.4	2.60	.11	13.3	132	13.7	5.5	.2	1.2	0.85	21.4	96
Ap$_2$	6-14	7.1	2.10	.10	12.3	138	13.0	5.3	.2	.9	1.00	20.3	95
A-C	14-22	7.2	1.40				14.7	6.8	.2	1.3	0.75	23.7	97
C$_1$	22-30	7.4	0.60				12.6	6.3	.2	1.4	0.61	21.1	97
C$_2$	30-38	7.6	0.44				12.9	7.4	.3	.8	0.26	21.6	99
C$_3$	38-42	7.4	0.35				11.4	5.6	.2	.6	0.55	18.3	97

Soil Profile No. 19. BALDWIN SILT LOAM, SALTY VARIANT

Sampled from a level field used for sugarcane in an area that has been reclaimed from the brackish water marsh; 3/4 mile southwest of the headquarters Ivanhoe Plantation; T. 15 S., R. 7 E., St. Mary Parish.

Ap_1	0-6"	Very dark gray (10YR 3/1) silt loam; strong thin and thick platy structure; firm; pH 6.2.
Ap_2	6-12"	Black (10YR 2/1) silt loam with thin lenses of grayish-brown (10YR 5/2) silt loam; strong thin and thick platy structure; firm; pH 7.0.
A-C	12-18"	Very dark gray (10YR 3/1) silty clay with many fine faint mottles of dark yellowish-brown (10YR 4/4); massive; plastic wet; few small black and brown concretions; pH 7.5.
C_1	18-28"	Dark grayish-brown (10YR 4/2) silty clay loam mottled with very dark gray (10YR 3/1); massive; friable; contains a few small brown and black concretions; pH 7.5.
C_2	28-42"	Dark grayish-brown (10YR 4/2) very fine sandy loam, mottled with dark yellowish-brown and dark gray (10YR 4/1); massive; friable; few brown and black concretions; pH 7.8.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acidity	CEC	Base Sat. %
							----------meq/100g					----------	
Ap_1	0-6	6.9	2.10	.11	12.3	69	9.4	5.6	.2	4.9	1.10	21.2	95
Ap_2	6-12	7.1	1.80	.09	11.6	62	10.3	6.2	.2	4.7	0.95	22.3	96
A-C	12-18	7.1	1.10	.06	10.6		10.8	7.8	.3	6.5	0.65	26.0	97
C_1	18-28	7.1	0.63	.03	11.1		9.5	6.6	.2	4.8	0.57	21.7	97
C_2	28-42	7.1	0.44	.02	10.7		7.6	5.6	.2	3.9	0.63	18.0	97

Soil Profile No. 20. BALDWIN SILTY CLAY LOAM

Samples from a level field used for sugarcane, located 5/16 mile southeast of Columbia Store, Katy Plantation; Sec. 10, T. 14 S., R. 9 E., St. Mary Parish.

Ap_1	0-5"	Very dark grayish-brown (10YR 3/2) silty clay loam; moderate medium granular structure; friable; pH 6.0.
Ap_2	5-10"	Very dark gray (10YR 3/1) clay mottled with pale brown (10YR 6/3) and light yellowish-brown (10YR 6/4); moderate to strong thick platy structure; pH 6.0.
B_{2t}	10-16"	Light brownish-gray (10YR 6/2) clay mottled with light gray (10YR 7/1), grayish-brown (10YR 5/2) and dark gray (10YR 4/1); strong medium and fine subangular blocky structure; patchy dark gray clay skins on ped faces; very firm moist; pH 6.0.
B_3	16-30"	Light yellowish-brown (10YR 6/4) clay mottled with gray (10YR 6/1-5/1), dark gray (10YR 4/1) and yellowish-brown (10YR 5/4); weak fine and medium subangular blocky structure; plastic wet; pH 7.0.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Extractable Bases Mg	Extractable Bases K	Extractable Bases Na	Ext. Acidity	CEC	Base Sat. %
							meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	meq/100g	
Ap_1	0-5	5.7	2.60	.13	11.7	23	12.3	6.1	.5	.2	4.9	24.1	80
Ap_2	5-10	5.6	2.30	.11	12.2	2	15.0	8.5	.7	.5	7.7	32.4	77
B_{2t}	10-16	5.7	1.60	.09	10.6		16.4	11.3	.9	.8	6.2	35.6	83
B_3	16-30	6.5	0.91	.06	8.6		16.2	11.2	.7	.9	3.6	32.6	89

Mineralogical Characteristics of the < 2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmorillonite %	Illite %	Kaolinite %	Quartz %
Ap_1	0-5	24.1	10-40	10-40	< 10	< 10
Ap_2	5-10	32.4	10-40	10-40	10-40	< 10
B_{2t}	10-16	35.6	10-40	10-40	10-40	< 10
B_3	16-30	32.6	10-40	10-40	10-40	< 10

(Continued)

Soil Profile No. 20. BALDWIN SILTY CLAY LOAM (Continued)

Chemical Composition of the Soil

	Ap_1	Ap_2	B_{2t}	B_3
	0-5	5-10	10-16	16-30
	Per cent			
SiO_2	73.02	68.09	64.34	67.66
TiO_2	00.44	00.45	00.53	00.54
Al_2O_3	13.16	16.22	18.50	16.56
Fe_2O_3	3.26	4.29	5.37	4.74
MnO	00.06	00.05	00.05	00.10
CaO	00.74	00.59	00.60	00.71
MgO	00.93	1.24	1.71	1.57
K_2O	1.79	1.92	1.92	2.01
Na_2O	1.59	1.53	1.55	1.80
P_2O_5	00.14	00.15	00.12	00.16
Ignition Loss	5.53	5.94	6.06	4.93
Total	100.66	100.47	100.76	100.78

Chemical Composition of the $<$ 2 Microns Clay

	Ap_1	Ap_2	B_{2t}	B_3
	0-5	5-10	10-16	16-30
	Per cent			
SiO_2	52.99	53.26	53.71	54.65
TiO_2	00.80	00.78	00.75	00.74
Al_2O_3	22.05	23.48	23.45	22.01
Fe_2O_3	6.93	7.40	7.19	7.13
MnO	00.12	00.06	00.04	00.07
CaO	00.92	00.86	00.81	00.98
MgO	2.02	2.31	2.47	2.59
K_2O	1.84	1.75	1.80	1.76
Na_2O	00.27	00.24	00.26	00.26
P_2O_5	00.32	00.18	00.17	00.13
Ignition Loss	12.43	10.49	10.30	9.50
Total	100.69	100.79	100.95	99.82

Soil Profile No. 21. BALDWIN SILTY CLAY LOAM

Samples from a level field used for sugarcane production, located 1 1/8 miles northeast of Columbia Store, Katy Plantation; Sec. 50, T. 14 S., R. 9 E., St. Mary Parish.

Ap$_1$	0-6"	Very dark grayish-brown (10YR 3/2) silty clay loam; moderate medium granular structure; friable; pH 6.0.
Ap$_2$	6-10"	Very dark gray (10YR 3/1) silty clay loam; moderate thin and thick platy structure; firm; pH 6.0.
B$_{2t}$	10-24"	Very dark grayish-brown (10YR 3/2) clay mottled with brown (10YR 5/3) and grayish-brown (10YR 5/2); blocky structure with patchy dark clay skins on ped faces; plastic wet; pH 6.0.
C	24-30"	Pale brown (10YR 6/3) clay mottled with light brownish-gray (10YR 6/2) and dark gray (10YR 4/1) massive; plastic wet; few small brown concretions; pH 7.0.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Extractable Bases Mg	Extractable Bases K	Extractable Bases Na	Ext. Acidity	CEC	Base Sat. %
							meq/100g						
Ap$_1$	0-6	5.7	2.60	.13	11.9	43	10.8	3.4	.3	.3	5.2	20.0	74
Ap$_2$	6-10	5.6	3.10	.13	13.8	7	10.7	4.0	.3	.4	7.9	23.2	66
B$_2$t	10-24	5.5	2.00	.10	11.5	2	16.0	6.2	.6	.5	6.4	29.7	78
C	24-30	6.5	0.81	.06	8.2	34	17.1	6.9	.5	.5	1.8	26.8	93

Mineralogical Characteristics of the < 2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmorillonite %	Illite %	Kaolinite %	Quartz %
Ap$_1$	0-6	20.0	10-40	10-40	< 10	< 10
Ap$_2$	6-10	23.2	10-40	10-40	10-40	< 10
B$_{2t}$	10-24	29.7	10-40	10-40	10-40	< 10
C	24-30	26.8	10-40	10-40	10-40	< 10

(Continued)

Soil Profile No. 21. BALDWIN SILTY CLAY LOAM (Continued)

Chemical Composition of the Soil

	Ap_1 0-6	Ap_2 6-10	B_{2t} 10-24	C 24-30
	-----	-----Per cent-----	-----	-----
SiO_2	75.54	73.64	66.65	68.49
TiO_2	00.50	00.51	00.54	00.54
Al_2O_3	12.40	13.52	18.16	16.97
Fe_2O_3	2.58	3.04	4.59	4.17
MnO	00.02	00.01	00.03	00.09
CaO	00.52	00.51	00.67	00.76
MgO	00.77	00.86	1.65	1.63
K_2O	1.63	1.57	1.44	1.96
Na_2O	1.41	1.51	1.32	1.59
P_2O_5	00.15	00.18	00.10	00.09
Ignition Loss	4.12	5.26	5.38	3.95
Total	100.64	100.62	100.54	100.14

Chemical Composition of the <2 Microns Clay

	Ap_1 0-6	Ap_2 6-10	B_{2t} 10-24	C 24-30
	-----	-----Per cent-----	-----	-----
SiO_2	51.91	53.09	52.01	54.27
TiO_2	00.85	00.70	00.74	00.73
Al_2O_3	21.97	21.16	22.74	21.96
Fe_2O_3	6.01	6.46	7.73	7.39
MnO	00.05	00.02	00.03	00.06
CaO	1.00	00.73	00.87	1.04
MgO	2.01	1.89	2.20	2.37
K_2O	1.95	1.65	2.01	2.10
Na_2O	00.31	00.25	00.30	00.32
P_2O_5	00.29	00.25	00.14	00.11
Ignition Loss	14.33	14.07	11.35	9.52
Total	100.68	100.27	100.12	99.87

Soil Profile No. 22. BALDWIN SILTY CLAY LOAM

Sampled from a level sugarcane field located 3/8 mile southwest of Columbia sugar mill; on Katy Plantation; Sec. 13, T. 14 S., R. 9 E., St. Mary Parish.

Ap_1	0-4"	Very dark grayish-brown (10YR 3/2) silty clay loam; moderate medium granular structure; friable; pH 6.0.
Ap2	4-6"	Very dark grayish brown (10YR 3/2) silty clay loam; moderate thick platy structure; firm moist.
B_{21t}	6-18"	Olive brown (2.5Y 4/4) clay, mottled with brown (10YR 5/3) and grayish-brown (2.5Y 5/2); strong subangular blocky structure with patchy black ped coatings; plastic wet; pH 6.5.
B_{22t}	18-30"	Grayish-brown (2.5Y 5/2) silty clay mottled with yellowish-brown (10YR 5/4); moderate medium subangular blocky structure with patchy black ped coatings; plastic wet; pH 8.0.
C_g	30-42"	Gray (10YR 6/1) silty clay loam mottled with yellowish-brown (10YR 5/4); massive; friable; few brown concretions; pH 8.2.

Chemical Characteristics

Soil Hori-zon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acid-ity	CEC	Base Sat. %
							----------	----------	meq/100g	----------	----------	----------	
Ap_1	0-4	6.5	2.20	.10	12.5	24	18.6	5.5	.3	.4	2.70	27.4	90
Ap_2	4-6	6.3	2.10	.11	10.8	27	18.3	6.7	.3	.5	2.80	28.6	90
B_{21t}	6-18	6.5	1.10	.06	10.6		22.4	9.5	.4	.8	1.70	34.8	95
B_{22t}	18-30	7.5	0.76	.05	9.8		19.4	10.5	.4	1.1	0.42	31.8	99
C_g	30-42	7.5	0.68	.04	9.9		19.3	10.3	.4	1.2	0.35	31.5	99

Soil Profile No. 23. CYPREMORT VERY FINE SANDY LOAM

Sampled from a level to gently undulating field used for sugarcane and corn located on Mr. De Gravelle's farm, ¼ mile southeast of house; Sec. 40., T. 14 S., R. 10 E., St. Mary Parish.

Ap_1	0-4"	Dark grayish-brown (10YR 4/2) very fine sandy loam; granular structure; friable; pH 5.0.
Ap_2	4-10"	Dark grayish-brown (10YR 4/2) very fine sandy loam mottled with dark gray (10YR 4/1); platy structure; firm; pH 5.0.
B_{2t}	10-16"	Grayish-brown (10YR 5/2) silty clay loam mottled with yellowish-brown (10YR 5/6); blocky structure with patchy ped coatings of very dark gray (10YR 3/1); friable; pH 5.5.
B_3	16-24"	Grayish-brown (10YR 5/2) very fine sandy loam mottled with dark gray (10YR 4/1); weak subangular blocky structure with patchy ped coatings of very dark gray (10YR 3/1); friable; pH 6.3.
C_g	24-42"	Light brownish-gray (10YR 6/2) very fine sandy loam mottled with yellowish-brown (10YR 5/6); massive; friable; pH 6.3.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca meq/100g	Mg meq/100g	K meq/100g	Na meq/100g	Ext. Acidity meq/100g	CEC meq/100g	Base Sat. %
Ap_1	0-4	5.4	1.60	.08	11.2	6	6.0	2.0	.4	.2	4.5	13.1	66
Ap_2	4-10	5.6	1.50	.08	11.0	4	6.3	2.7	.4	.2	4.4	14.0	69
B_{2t}	10-16	5.7	0.86			1	9.8	5.1	.3	.4	3.1	18.8	87
B_3	16-24	6.4	0.30			9	7.4	3.7	.2	.5	1.6	13.4	88
C_g	24-42	6.6	0.27			12	9.4	4.5	.3	.6	1.7	16.5	90

(Continued)

Soil Profile No. 23. CYPREMORT VERY FINE SANDY LOAM (Continued)

Chemical Composition of the Soil

	Ap_1 0-4	Ap_2 4-10	B_{2t} 10-16	B_3 16-24	C_g 24-42
	Per cent				
SiO_2	79.92	79.06	72.60	76.43	76.04
TiO_2	00.52	00.61	00.58	00.51	00.53
Al_2O_3	10.19	10.25	14.11	11.88	12.53
Fe_2O_3	1.90	1.95	3.40	2.67	2.73
MnO	00.01	00.02	00.02	00.03	00.05
CaO	00.72	00.64	00.93	1.32	1.02
MgO	00.57	00.66	1.01	00.86	00.90
K_2O	1.74	1.76	1.84	2.05	2.10
Na_2O	1.31	1.25	1.30	1.62	1.80
P_2O_5	00.05	00.04	00.03	00.08	00.09
Ignition Loss	3.14	3.15	3.92	2.15	2.31
Total	100.07	99.66	99.74	99.60	100.10

Soil Profile No. 24. CYPREMORT VERY FINE SANDY LOAM

Sampled and described from a field planted to sugarcane and soybeans having a slope of one to two per cent; located on Albania Plantation, 4/10 mile northeast of Albania sugar mill; Sec. 54, T. 13 S., R. 8 E., St. Mary Parish.

Ap$_1$	0-4"	Brown (10YR 5/3) very fine sandy loam; granular structure; friable; pH 6.0.
Ap$_2$	4-12"	Pale brown (10YR 6/3) very fine sandy loam, mottled with yellowish-brown and dark gray, moderate thick platy structure; firm; pH 5.5.
B$_{2t}$	12-30"	Mottled light brownish-gray (10YR 6/2) brown (10YR 5/3) and yellowish-brown (10YR 5/6) silty clay loam; moderate medium and coarse subangular blocky structure with patchy dark ped coatings; friable; pH 5.5.
C$_g$	30-40"	Light brownish-gray (10YR 6/2) silty clay loam mottled with yellowish-brown (10YR 5/6); massive; slightly plastic moist; a few brown and black concretions. pH 5.5.

Chemical Characteristics

Soil Hori-zon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acid-ity	CEC	Base Sat. %
							----------	----------	meq/100g	----------	----------	----------	
Ap$_1$	0-4	5.7	.98			61	8.0	3.2	.2	.3	4.7	16.4	71
Ap$_2$	4-12	5.2	.42			59	7.6	4.3	.4	.6	7.7	20.5	62
B$_{2t}$	12-30	5.1	.34				8.9	5.7	.5	.9	5.8	21.7	73
C$_g$	30-42	5.2	.33				10.1	5.8	.4	.6	6.6	23.5	72

Soil Profile No. 25. CYPREMORT SILTY CLAY LOAM

Sampled and described from an idle field having slopes of 2 to 3 per cent located 6 miles northeast of Point Chevreuil, along the east side of Bayou Sale; northeastern part of Sec. 3, T. 16 S., R. 9 E., St. Mary Parish.

Ap_1	0-6"	Brown (10YR 5/3) silty clay loam; moderate granular structure; friable; pH 6.0.
Ap_2	6-11"	Brown (10YR 5/3) silty clay loam; weak platy structure; firm moist.
B_{2t}	11-18"	Brown (10YR 5/3) silty clay loam, mottled brownish-yellow, moderate medium subangular blocky structure; few dark gray clay skins; friable; a few black and brown concretions; pH 5.0.
B_3	18-24"	Light yellowish-brown (10YR 6/4) silty clay loam mottled brownish-yellow; weak blocky structure; friable; pH 5.0.
C	24-44"	Pale brown (10YR 6/3) very fine sandy loam; massive; friable; few brown and black concretions; pH 5.2.

Chemical Characteristics

Soil Hori-zon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acid-ity	CEC	Base Sat. %
							meq/100g						
Ap_1	0-6	5.5	3.30	.17	10.9	4	7.9	5.0	.5	.3	10.8	24.4	56
Ap_2	6-11	5.3	1.30	.07	10.5	4	6.3	4.8	.3	.4	10.6	22.4	53
B_{2t}	11-18	5.1	0.80	.04	10.6		6.4	5.8	.4	.6	10.0	23.2	53
B_3	18-24	5.0	0.51	.03	10.5		5.7	4.0	.3	.7	7.0	17.7	60
C	24-44	5.3	0.40	.02			5.4	3.5	.2	1.0	4.9	14.9	67

Mineralogical Characteristics of the < 2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmor-illonite %	Illite %	Kaolinite %	Quartz %
Ap_1	0-6	24.4	> 40	10-40	10-40	< 10
Ap_2	6-11	22.4	> 40	10-40	10-40	< 10
B_{2t}	11-18	23.2	> 40	10-40	10-40	< 10
B_3	18-24	17.7	> 40	10-40	10-40	< 10
C	24-44	14.9	> 40	10-40	10-40	< 10

Soil Profile No. 26. IBERIA SILTY CLAY LOAM

Sampled and described from a level field in sugarcane located 9/16 mile east of Columbia Store, Katy Plantation; Sec. 9, T. 14 S., R. 9 E., St. Mary Parish.

Ap$_1$	0-7"	Very dark gray (10YR 3/1) silty clay loam; weak medium granular structure; slightly plastic wet; pH 7.0.
Ap$_2$	7-11"	Very dark gray (10YR 3/1) silty clay loam; moderate thick platy structure; firm; pH 7.0.
B$_{21t}$	11-13"	Black (10YR 2/1) clay, strong angular blocky structure; plastic wet; pH 8.0.
B$_{22t}$	13-26"	Very dark grayish-brown (10YR 3/2) clay mottled with light gray (10YR 7/1) and yellowish-brown (10YR 5/6); moderate mdeium angular blocky structure; plastic wet; pH 8.0.
C$_g$	26-40"	Gray (5Y 5/1) clay mottled with pale brown and light brownish-gray (10YR 6/2); massive; plastic; few brown concretions; pH 7.0.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acidity	CEC	Base Sat. %
							meq/100g						
Ap$_1$	0-7	6.8	3.20	.140	13.3	105	18.7	4.0	.6	.3	1.6	25.2	94
Ap$_2$	7-11	7.0	2.50	.097	13.1	72	18.9	4.0	.3	.4	1.3	25.0	95
B$_{21t}$	11-13	6.8	2.10	.080	12.2	9	20.6	5.0	.5	.5	1.3	27.8	95
B$_{22t}$	13-26	6.8	1.00	.057	10.4	10	17.7	5.4	.5	.5	1.1	25.2	96
C$_g$	26-40	6.7	0.71	.045	9.3	195	15.2	5.3	.6	.5	1.1	22.6	95

Mineralogical Characteristics of the < 2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmorillonite %	Illite %	Kaolinite %	Quartz %
Ap$_1$	0-7	25.2	> 40	10-40	10-40	< 10
Ap$_2$	7-11	25.0	> 40	10-40	10-40	< 10
B$_{21t}$	11-13	27.8	> 40	10-40	10-40	< 10
B$_{22t}$	13-26	25.2	> 40	10-40	10-40	< 10
C$_g$	26-40					

Soil Profile No. 26. IBERIA SILTY CLAY LOAM (Continued)

Chemical Composition of the Soil

	Ap_1 0-7	Ap_2 7-11	B_{21t} 11-13	B_{22t} 13-26	C_g 26-40
			Per cent		
SiO_2	73.58	74.20	70.92	70.87	72.35
TiO_2	00.52	00.53	00.58	00.63	00.60
Al_2O_3	11.97	12.14	13.92	13.98	13.62
Fe_2O_3	3.08	3.10	3.99	4.20	4.16
MnO	00.05	00.04	00.02	00.08	00.05
CaO	00.89	00.88	00.95	00.82	00.91
MgO	00.85	00.90	1.15	1.23	1.28
K_2O	1.90	1.87	1.97	2.03	2.01
Na_2O	1.35	1.31	1.43	1.27	1.30
P_2O_5	00.13	00.13	00.12	00.11	00.13
Ignition Loss	5.73	5.01	5.42	4.38	3.91
Total	100.05	100.10	100.51	99.60	100.32

Chemical Composition of the <2 Microns Clay

	Ap_1 0-7	Ap_2 7-11	B_{21t} 11-13	B_{22t} 13-26	C_g 26-40
			Per cent		
SiO_2	49.61	51.31	52.38	54.38	54.79
TiO_2	00.77	00.81	00.79	00.76	00.76
Al_2O_3	22.46	22.13	23.04	22.59	22.57
Fe_2O_3	6.48	6.31	6.80	7.13	7.30
MnO	00.07	00.05	00.04	00.03	00.05
CaO	1.75	1.82	1.59	1.33	1.29
MgO	2.14	2.22	2.52	2.28	2.51
K_2O	1.78	1.74	1.87	1.56	2.04
Na_2O	00.27	00.34	00.33	00.29	00.29
P_2O_5	00.38	00.28	00.15	00.14	00.17
Ignition Loss	14.51	13.26	11.26	9.43	8.41
Total	100.21	100.26	100.77	100.01	100.17

Soil Profile No. 27. IBERIA SILTY CLAY LOAM

Described and sampled from a level sugarcane field located 5/8 mile east of Columbia Store, Katy Plantation; Sec. 10, T. 14 S., R. 9 E., St. Mary Parish.

Ap$_1$	0-8"	Black (10YR 2/1) silty clay loam; granular structure; slightly firm moist; pH 6.2.
Ap$_2$	8-12"	Black silty clay loam; massive to weak platy structure; slightly firm moist; pH 6.5.
B$_{2t}$	12-24"	Light brownish-gray (2.5Y 6/2) clay mottled with yellowish-brown and gray; blocky structure; plastic wet; pH 7.0.
C	24-34"	Olive brown (2.5Y 4/4) clay mottled with yellowish-brown and gray; massive; plastic wet; pH 7.5.

Chemical Characteristics

Soil Hori-zon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	 Mg	 K	 Na	Ext. Acid-ity	CEC	Base Sat. %
							-----------------	-----meq/100g	-----	-----	-----	-----	
Ap$_1$	0-8	6.3	4.30	.17	14.5	89	20.8	7.0	.3	.2	4.40	32.8	88
Ap$_2$	8-12	6.6	3.90	.15	14.6	83	21.7	7.8	.3	.3	3.30	33.5	90
B$_{2t}$	12-24	7.1	1.30	.07	10.0		20.3	10.2	.4	.4	0.93	32.3	97
C	24-34	6.9	0.88	.05	9.6		16.0	8.6	.4	.3	0.66	25.9	97

Mineralogical Characteristics of the <2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmor-illonite %	Illite %	Kaolinite %	Quartz %
Ap$_1$	0-8	32.8	> 40	10-40	10-40	< 10
Ap$_2$	8-12	33.5	> 40	10-40	10-40	< 10
B$_{2t}$	12-24	32.3	> 40	10-40	10-40	< 10
C	24-34	25.9	> 40	10-40	10-40	< 10

(Continued)

Soil Profile No. 27. IBERIA SILTY CLAY LOAM (Continued)

Chemical Composition of the Soil

	Ap_1 0-8	Ap_2 8-12	B_{2t} 12-24	C 24-34
	Per cent			
SiO_2	72.17	71.09	68.76	70.83
TiO_2	00.61	00.63	00.64	00.64
Al_2O_3	12.08	13.65	15.66	15.06
Fe_2O_3	3.36	3.66	5.10	4.79
MnO	00.05	00.06	00.09	00.11
CaO	1.03	1.04	00.94	00.92
MgO	00.96	1.09	1.60	1.43
K_2O	1.84	1.82	1.89	1.90
Na_2O	1.70	1.61	1.59	1.73
P_2O_5	00.12	00.14	00.12	00.14
Ignition Loss	6.23	5.65	3.78	3.36
Total	100.15	100.44	100.27	100.91

Chemical Composition of the < 2 Microns Clay

	Ap_1 0-8	Ap_2 8-12	B_{2t} 12-24	C 24-34
	Per cent			
SiO_2	49.29	49.81	53.90	54.18
TiO_2	00.78	00.78	00.78	00.77
Al_2O_3	22.24	21.51	22.49	22.81
Fe_2O_3	5.74	6.22	6.91	7.02
MnO	00.07	00.06	00.07	00.05
CaO	1.92	1.94	1.49	1.46
MgO	2.14	2.23	2.69	2.57
K_2O	1.58	1.55	1.60	1.52
Na_2O	00.25	00.32	00.33	00.35
P_2O_5	00.31	00.15	00.22	00.15
Ignition Loss	15.79	15.10	9.10	8.97
Total	100.11	99.67	99.58	99.85

Soil Profile No. 28. IBERIA SILTY CLAY

Soil profile from a level field in sugarcane located on Home Place Plantation; Sec. 23, T. 14 S., R. 8 E., St. Mary Parish.

Ap_1	0-4"	Very dark gray (10YR 3/1) silty clay; strong fine angular blocky structure; very firm moist; pH 6.8.
Ap_2	4-10"	Very dark gray (10YR 3/1) silty clay; moderate thick platy structure; very firm moist; pH 7.0.
B_{21t}	10-22"	Very dark gray (10YR 3/1) clay; strong medium angular blocky structure; plastic wet; pH 8.0.
B_{22t}	22-28"	Dark gray (10YR 4/1) clay mottled with brown (10YR 5/3); strong medium angular blocky structure; plastic wet; few gray lime concretions; pH 8.0.
C	28-44"	Light yellowish-brown (10YR 6/4) silty clay loam mottled with gray (10YR 6/1); massive; friable; few lime concretions; pH 8.0.

Chemical Characteristics

Soil Hori-zon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acid-ity	CEC	Base Sat. %
							---------	---------	meq/100g	---------	---------	---------	
Ap_1	0-4	6.2	3.20			53	14.3	9.0	.1	.1	3.60	27.2	87
Ap_2	4-10	6.7	3.10			31	15.5	10.2	.1	.2	2.80	28.8	90
B_{21t}	10-22	7.5	2.40				19.9	14.6	.3	.3	0.77	35.8	98
B_{22t}	22-28	8.1	1.50				21.4	14.0	.3	.4		36.0	100
C	28-44	7.6	0.56				12.5	10.5	.2	.3	0.45	24.0	98

(Continued)

Soil Profile No. 28. IBERIA SILTY CLAY (Continued)

Chemical Composition of the Soil

	Ap_1 0-4	Ap_2 4-10	B_{21t} 10-22	B_{22t} 22-28	C 28-44
	Per cent				
SiO_2	74.67	74.11	70.45	69.26	74.06
TiO_2	00.91	00.95	00.90	00.93	00.92
Al_2O_3	11.94	12.48	14.62	14.44	13.81
Fe_2O_3	2.11	2.11	3.23	3.48	3.57
MnO	00.04	00.04	00.04	00.11	00.04
CaO	00.76	00.77	00.87	00.96	00.70
MgO	00.84	00.87	1.40	1.58	1.68
K_2O	1.70	1.69	1.73	1.73	2.11
Na_2O	1.61	1.59	1.58	1.55	1.62
P_2O_5	00.15	00.11	00.06	00.14	00.11
Ignition Loss	5.71	5.82	5.90	6.34	2.19
Total	100.44	100.54	100.53	100.52	100.81

Soil Profile No. 29. JEANERETTE SILT LOAM

Described and sampled from a level field in sugarcane located 1 3/8 miles southwest of the sugar mill, Albania Plantation; Sec. 41, T. 13 S., R. 8 E., St. Mary Parish.

Ap_1	0-8"	Very dark gray (10YR 3/1) silt loam; moderate medium granular structure; friable; few small brown and black concretions; pH 8.0.
Ap_2	8-11"	Very dark gray (10YR 3/1) silt loam; strong thick platy structure; firm; pH 8.0.
B_{21t}	11-15"	Black (10YR 2/1) silty clay loam; weak medium subangular blocky structure; friable; a few brown and black concretions; pH 8.0.
B_{22t}	15-20"	Dark gray (10YR 4/1) silty clay loam; strong medium angular blocky structure; friable; a few brown and black concretions; pH 8.0.
C_g	20-30"	Light brownish-gray (2.5Y 6/4) silt loam mottled with gray (10YR 6/1) and brown (10YR 5/3); massive; friable; few gray silica-lime concretions; few brown and black concretions; pH 8.0.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases				Ext. Acidity	CEC	Base Sat. %
							Ca	Mg	K	Na			
							meq/100g						
Ap_1	0-8	8.1	2.30			83	13.7	2.0	.1	.2		16.0	100
Ap_2	8-11	8.1	2.20			73	13.2	2.1	.1	.2		15.6	100
B_{21t}	11-15	8.2	3.10				17.1	3.1	.1	.2		20.6	100
B_{22t}	15-20	8.2	2.00				15.0	3.0	.2	.3		18.5	100
C_g	20-30	8.0	0.71				12.4	3.9	.1	.3		16.8	100

Soil Profile No. 30. JEANERETTE SILT LOAM

Described and sampled from a level sugarcane field located 1 3/4 miles southwest of Albania sugar mill, Sec. 67, T. 13 S., R. 8 E., St. Mary Parish.

Ap	0-6"	Black (10YR 2/1) silt loam, strong medium granular structure; friable; pH 8.0.
B_{21t}	6-16"	Black (10YR 2/1) silty clay loam; strong medium blocky structure; friable; pH 8.0.
B_{22t}	16-24"	Very dark gray (10YR 3/1) silty clay loam; strong medium blocky structure; friable; few gray silica-lime concretions; pH 8.0.
C_1	24-30"	Light olive brown (2.5Y 5/4) silty clay loam; massive; friable; few brown and black concretions; few lime concretions; pH 8.0.
C_2	30-42"	Light olive brown (2.5Y 5/4) mottled olive (5Y 5/3) silt loam; massive; friable; few brown and and black concretions; pH 8.0.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Extractable Bases Mg	Extractable Bases K	Extractable Bases Na	Ext. Acidity	CEC	Base Sat. %
							meq/100g						
Ap	0-6	7.8	4.30	.18	12.2	94	9.8	4.3	.1	.3		14.4	100
B_{21t}	6-16	8.0	3.90	.32	12.1	39	17.6	5.9	.1	.6		24.2	100
B_{22t}	16-24	8.1	1.90			58	12.9	5.7	.1	.3		19.1	100
C_1	24-30	8.2	0.84			200	13.2	5.9	.1	.5		19.8	100
C_2	30-42	8.1	0.75			240	12.7	5.9	.1	.4		19.2	100

(Continued)

Soil Profile No. 30. JEANERETTE SILT LOAM (Continued)

Chemical Composition of the Soil

	Ap 0-6	B_{21t} 6-16	B_{22t} 16-24	C_1 24-30	C_2 30-42
	-----------------	--------------Per	cent--------------	-----------------	-----------------
SiO_2	71.81	63.42	70.28	75.33	74.89
TiO_2	00.60	00.56	00.60	00.66	00.66
Al_2O_3	9.82	9.04	10.26	11.67	11.90
Fe_2O_3	1.82	1.83	2.22	2.19	3.52
MnO	0.03	00.04	00.06	00.09	00.06
CaO	3.80	8.90	5.95	1.76	1.24
MgO	1.03	1.16	1.20	1.22	1.13
K_2O	1.11	00.98	1.10	1.28	1.36
Na_2O	1.06	00.83	1.00	1.20	1.16
P_2O_5	00.10	00.08	00.09	00.10	00.11
Ignition Loss	8.17	12.29	7.87	3.89	3.96
Total	99.35	99.13	100.63	99.39	99.72

Mineralogical Characteristics of the < 2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmorillonite %	Illite %	Kaolinite %	Quartz %
Ap	0-6	14.4	> 40		10-40	< 10
B_{21t}	6-16	24.2	> 40		10-40	< 10
B_{22t}	16-24	19.1	> 40	10-40	10-40	< 10
C_1	24-30	19.8				
C_2	30-42	19.2				

Soil Profile No. 31. JEANERETTE SILT LOAM

Sampled from a level sugarcane field located 1¼ miles southwest of Albania sugar mill, southern part of Sec. 41, T. 13 S., R. 8 E., St. Mary Parish.

Ap	0-6"	Very dark brown (10YR 2/2) silt loam; moderate fine granular structure; friable; pH 6.5.
B_{21t}	6-16"	Black (10YR 2/1) silty clay loam; weak medium blocky structure; slightly firm moist; pH 7.5.
B_{22t}	16-24"	Very dark gray (10YR 3/1) silty clay loam; weak medium blocky structure; firm moist; few brown, black and gray concretions; pH 8.0.
C_1	24-30"	Light olive brown (2.5Y 5/4) very fine sandy loam; massive; friable; few brown and black concretions; pH 7.5.
C_2	30-42"	Light olive brown (2.5Y 5/4) very fine sandy loam with thin lenses of olive brown (2.5Y 4/4) silty clay loam; massive; friable; pH 8.0.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acidity	CEC	Base Sat. %
							meq/100g						
Ap	0-6	6.5	2.30			45	19.5	3.6	.2	.2	2.6	26.2	90
B_{21t}	6-16	7.0	2.20			35	20.0	5.1	.2	.3	1.8	27.4	93
B_{22t}	16-24	7.7	1.70				14.5	5.6	.2	.9		21.1	100
C_1	24-30	7.9	0.55				7.7	4.8	.1	.3		12.9	100
C_2	30-42	7.9	0.35				7.4	4.9	.1	.3		12.7	100

Soil Profile No. 32. JEANERETTE SILT LOAM, THIN SOLUM PHASE

Sampled from a level sugarcane field located ¼ mile southwest of Ivanhoe Plantation headquarters; southeastern part of T. 14 S., R. 7 E., St. Mary Parish.

Ap_1	0-4"	Very dark grayish-brown (10YR 3/2) silt loam; platy structure; firm; pH 7.5.
Ap_2	4-8"	Very dark grayish-brown (10YR 3/2) silt loam; platy structure; firm; pH 7.5.
B_{21t}	8-12"	Very dark grayish-brown (10YR 3/2) silty clay loam; weak medium subangular blocky structure; firm; pH 7.5.
B_{22t}	12-18"	Grayish-brown (10YR 5/2) silty clay loam; weak medium subangular blocky structure; friable; few brown and black concretions; few lime concretions; pH 7.5.
C_1	18-28"	Light brownish-gray (10YR 6/2) silt loam; massive; firm; few iron and lime concretions; pH 8.0.
C_2	28-32"	Dark grayish-brown (10YR 4/2) silt loam mottled with gray (10YR 6/1); massive; friable; few lime concretions; pH 8.0.
C_3	32-42"	Pale brown (10YR 6/3) very fine sandy loam mottled with gray (10YR 6/1) massive; friable; pH 8.0.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Extractable Bases Mg	Extractable Bases K	Extractable Bases Na	Ext. Acidity	CEC	Base Sat. %
							meq/100g						
Ap_1	0-4	7.5	2.40			58	14.1	3.5	.1	.4		18.1	100
Ap_2	4-8	7.5	2.10			54	13.5	4.4	.1	.4		18.4	100
B_{21t}	8-12	7.9	0.86				14.5	5.9	.2	.4		21.0	100
B_{22t}	12-18	8.1	0.70				17.4	6.4	.2	.6		24.6	100
C_1	18-28	8.3	0.53				16.7	5.7	.1	.8		23.3	100
C_2	28-32	8.1	0.39				15.5	4.9	.1	.8		21.3	100
C_3	32-42	8.3	0.31				13.2	4.3	.1	.4		18.1	100

Soil Profile No. 33. PATOUTVILLE VERY FINE SANDY LOAM

Described and sampled from a sugarcane field having level and gently undulating slopes of less than one per cent; located 1 mile southwest of Albania sugar mill; Sec. 40-41, T. 13 S., R. 8 E., St. Mary Parish.

Ap_1	0-4"	Dark grayish-brown (10YR 4/2) very fine sandy loam; moderate fine granular structure; friable; pH 5.5.
Ap_2	4-12"	Dark gray (10YR 4/1) very fine sandy loam; moderate medium platy structure; firm; pH 5.5.
B_{21t}	12-20"	Dark brown (7.5YR 3/2) silty clay loam mottled with reddish-brown (5YR 5/4) and yellowish-red (5YR 4/8); moderate medium subangular blocky structure; pH 5.8.
B_{22t}	20-30"	Yellowish-brown (10YR 5/8) silty clay loam, mottled with dark gray (10YR 4/1), moderate medium subangular blocky structure with patchy dark gray ped coatings; friable; pH 6.0.
C	30-42"	Grayish-brown (10YR 5/2) silt loam mottled with yellowish-brown (10YR 5/8) and gray (10YR 6/1); massive; friable; pH 6.8. A few brown and black concretions in each horizon.

Chemical Characteristics

							Extractable Bases				Ext.		
Soil Hori- zon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Ca	Mg	K	Na	Acid- ity	CEC	Base Sat. %
							----------	----------	meq/100g	----------	----------	----------	
Ap_1	0-4	6.2	1.40	.07	11.3	3	3.3	1.5	.2	.3	3.2	8.4	62
Ap_2	4-12	6.2	1.40	.07	11.9	2	3.5	1.7	.2	.2	3.3	8.9	63
B_{21t}	12-20	6.3	1.30	.08	8.7		5.5	5.7	.3	.6	4.0	16.0	75
B_{22t}	20-30	6.6	0.65	.04	8.8		5.4	7.2	.3	.7	2.4	16.0	85
C	30-42	6.6	0.42	.03	8.5		4.7	6.0	.3	.6	2.0	13.6	85

Mineralogical Characteristics of the < 2 Microns Clay

Horizon	Depth, Inches	CEC meq/100g	Montmor- illonite %	Illite %	Kaolinite %	Quartz %
Ap_1	0-4	8.4	10-40	10-40	10-40	< 10
Ap_2	4-12	8.9	10-40	10-40	10-40	< 10
B_{21t}	12-20	16.0	> 40	10-40	10-40	< 10
B_{22t}	20-30	16.0	10-40	10-40	10-40	< 10
C	30-42	13.6	> 40	10-40	10-40	< 10

Soil Profile No. 34. PATOUTVILLE SILT LOAM

Described and sampled from a sugarcane field having undulating slopes of less than one per cent, located 2 miles southeast of Albania sugar mill; western part of Sec. 69, T. 13 S., R. 8 E., St. Mary Parish.

Ap_1	0-4"	Very dark grayish-brown (10YR 3/2) silt loam; granular structure; friable; many small brown and black concretions on the surface; pH 5.8.
Ap_2	4-7"	Very dark grayish-brown (10YR 3/2) silt loam mottled with brown (10YR 5/3); platy structure; firm; pH 5.8.
B_{21t}	7-10"	Dark yellowish-brown (10YR 4/4) silty clay loam, mottled with very dark grayish-brown (10YR 3/2), and strong brown (7.5YR 5/6); subangular blocky and prismatic structure; firm; few brown and black concretions; pH 5.8.
B_{22t}	10-22"	Very dark grayish-brown (10YR 3/2) silty clay loam mottled with grayish-brown (10YR 5/2) and dark brown; moderate medium subangular blocky and prismatic structure; firm; few brown and black concretions; pH 5.8.
B_3	22-36"	Grayish-brown (2.5Y 5/2) silty clay loam, mottled with brown (10YR 5/3); weak medium subangular blocky structure; firm; few brown and black concretions; pH 6.5.
C_g	36-48"	Gray (10YR 6/1) silt loam, mottled with light olive brown (2.5Y 5/4); massive; friable; few brown and black concretions; pH 6.5.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases Ca	Mg	K	Na	Ext. Acidity	CEC	Base Sat. %
							---meq/100g---						
Ap_1	0-4	6.1	1.80	.089	11.9	7	5.8	3.4	.3	.3	3.8	13.5	72
Ap_2	4-7	6.1	1.70	.079	12.2	2	5.4	2.8	.1	.4	3.6	12.3	71
B_{21t}	7-10	6.2	1.40			1	8.1	4.1	.1	.5	3.4	16.4	79
B_{22t}	10-22	6.6	0.63			1	6.1	5.7	.2	1.0	2.3	15.3	85
B_3	22-36	7.0	0.45			2	6.8	5.6	.2	.9	1.5	15.1	90
C_g	36-48	7.0	0.25			4	6.5	5.3	.1	1.2	1.4	14.5	90

(Continued)

Soil Profile No. 34. PATOUTVILLE SILT LOAM (Continued)

Chemical Composition of the Soil

	Ap_1 0-4	Ap_2 4-7	B_{21t} 7-10	B_{22t} 10-22	B_3 22 36	C_g 36-48
	Per cent					
SiO_2	81.80	78.16	76.02	73.45	73.25	75.53
TiO_2	00.65	00.67	00.67	00.66	00.67	00.64
Al_2O_3	8.82	10.38	13.47	13.64	13.92	12.07
Fe_2O_3	1.63	2.40	3.25	3.82	4.04	3.55
MnO	00.05	00.08	00.10	00.09	00.07	00.08
CaO	00.60	00.56	00.67	00.55	00.58	00.87
MgO	00.45	00.49	00.81	00.83	00.88	00.78
K_2O	1.27	1.20	1.24	1.34	1.47	1.63
Na_2O	00.85	00.83	00.79	00.73	00.78	1.01
P_2O_5	00.06	00.04	00.03	00.02	00.02	00.09
Ignition Loss	3.41	5.62	3.70	4.44	3.98	3.05
Total	99.59	100.43	100.75	99.57	99.66	99.22

Soil Profile No. 35. PATOUTVILLE SILT LOAM

Described and sampled from a level to undulating field having slopes of one per cent or less, located 1 mile southwest of Albania sugar mill; western part of Sec. 40, T. 13 S., R. 8 E., St. Mary Parish.

Ap_1	0-4"	Dark grayish-brown (10YR 4/2) silt loam; granular structure; friable; pH 5.8.
Ap_2	4-7"	Very dark grayish-brown (10YR 3/2) silt loam; platy structure; firm; pH 6.0.
B_{21t}	7-14"	Very dark grayish-brown (10YR 3/2) silty clay loam mottled strong brown (7.5YR 5/6); moderate medium subangular blocky and prismatic structure; firm; pH 6.0.
B_{22t}	14-20"	Very dark grayish-brown (10YR 3/2) silty clay loam; subangular blocky and prismatic structure; firm; pH 6.5.
B_3	20-36"	Grayish-brown (2.5Y 5/2) silty clay loam mottled with olive brown (2.5Y 4/4); weak medium subangular blocky structure; firm; pH 6.5.
C_g	36-48"	Gray (10YR 6/1) silt loam mottled with brown (10YR 5/3); massive; friable; pH 6.5. Few to many brown and black concretions on the surface and throughout the profile.

Chemical Characteristics

Soil Horizon	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	P ppm	Extractable Bases				Ext. Acidity	CEC	Base Sat. %
							Ca	Mg	K	Na			
							meq/100g						
Ap_1	0-4	5.8	1.70			2	3.1	1.5	.2	.3	4.8	9.9	52
Ap_2	4-7	6.1	1.50			2	3.4	2.1	.2	.3	3.2	9.1	65
B_{21t}	7-14	6.2	1.10				5.8	3.5	.2	1.0	3.0	13.6	78
B_{22t}	14-20	6.6	0.52				8.0	5.8	.2	.7	1.6	16.3	90
B_3	20-36	6.6	0.51				6.7	5.7	.2	.8	1.4	14.8	90
C	36-48	6.3	0.25				6.7	5.5	.2	1.0	2.0	15.5	87

Properties of the Organic Soils and Clays of the Coastal Marshlands and Swamps

The "wet lands" of St. Mary Parish occur along the borders of the natural-levee ridges. These level areas and depressions range from near sea level to elevations of about 5 feet. They have a water table at or near the soil surface, or they are covered with water to a depth of 2 to 4 inches for a major part of each year. Soil materials of the wet lands are gray and dark gray silts and clays overlain in large areas by organic materials.

The swamps occupy narrow bands that are less than 1 mile to more than 2 miles wide along the north and south borders of the soils used for farming. The soil materials are gray and dark gray alluvial silts and clays overlain in places by 1 foot to more than 8 feet of organic materials. The dominant vegetation of the swamps includes the following trees: cypress, tupelogum, swamp maple, bay, oak and ash.

The coastal marshlands occur along the coastline of the Gulf of Mexico, extending northward to the swamps in a treeless area ranging in width from 1 mile to more than 10 miles. This area is a broad, flat or depressed plain at near sea level with an imperceptible slope toward the Gulf. The monotony of the coastal marshlands is broken in places by low, narrow, natural-levee ridges extending into the marshlands. Much of the area is inundated to a depth of 3 to 4 inches most of the time, and parts are flooded by the normal daily tides of 18 inches or more. Some areas are frequently flooded by streams that flow into and across the marshlands. All of the coastal marshlands are inundated to depths of 6 to 10 feet or more by the occasional storm tides. Soil materials of the coastal marshlands include alluvial silts and clays deposited by streams and silty and clayey sediments washed from the floor of the Gulf of Mexico and redeposited by waves and tides. The mineral soil materials are overlain in large areas by layers of organic materials ranging in thickness from 1 foot to more than 11 feet.

Classification of the soil materials of the coastal marshlands is based on the contents of organic matter in the surface layers and on the degree of decomposition or preservation of the organic materials. The soil materials classified as peats and mucks have surface layers that contain 28 per cent or more organic matter. Clayey mucks and silty mucks have surface layers that contain from 16 to 27 per cent organic matter. Mucky clays and mucky silty clays contain from 11 to 15 per cent organic matter, and clays have surface layers with an organic matter content of 10 per cent or less.

Organic soil materials in which the parts of plants are well preserved and easily identified are classified as peats. Organic materials that are decomposed to the extent that most plant tissues are destroyed are classified as mucks. Colors of the peats and mucks range from drak brown to black. When dry, the peats commonly have a coarse, fibrous structure and the mucks have a granular structure.

There are distinct differences in the types of vegetation growing in the coastal marshlands which are the result of differences in the degree of salinity of the areas and differences in the salt tolerance of the grasses, sedges and forbs that grow in the marshlands. The salinity of any area of the coastal marshlands depends mainly on the length of time that fresh water or salty water has had dominance in the area. Rainfall and floodwaters from streams are effective in the removal of salts brought into some areas of coastal marshlands by tides. Since environmental adjustments of the plants to changes in salinity conditions are slow, it is not uncommon to find plants in the coastal marshlands growing in areas having a salinity content outside of the range of their normal salt tolerance. The vigor and the height of growth of some marsh plants are indications of their degree of adjustment to saline or fresh water conditions.

The classification of salinity conditions in the coastal marshlands is based on the salt content of the soils. The following salinity classes are identical with those used by Penfound and Hathaway *(11)*[1]: Fresh Water marsh, 0 to 0.50 per cent salt; Brackish marsh, 0.50 to 2 per cent salt; Salt Water marsh, more than 2 per cent salt.

The following section includes the location, description and chemical data for each of the 71 soil profiles of coastal marshland and associated swamp soils. The dominant plants and their height of growth are noted for most sites in the marshes. Since sodium chloride and total salt values were calculated on air-dry weights of the samples, the values are much higher than those found in the soils under normal conditions of moisture. The salt content of soils at the different sites as measured in the field with a Wheatstone bridge is in close agreement with the salt tolerance of the plants found growing at the sample sites. Each soil profile is located by a number on the map of the parish on pages 46-47.

The botanical names and common names of the dominant plants of the coastal marshlands of St. Mary Parish are given in Table 1.

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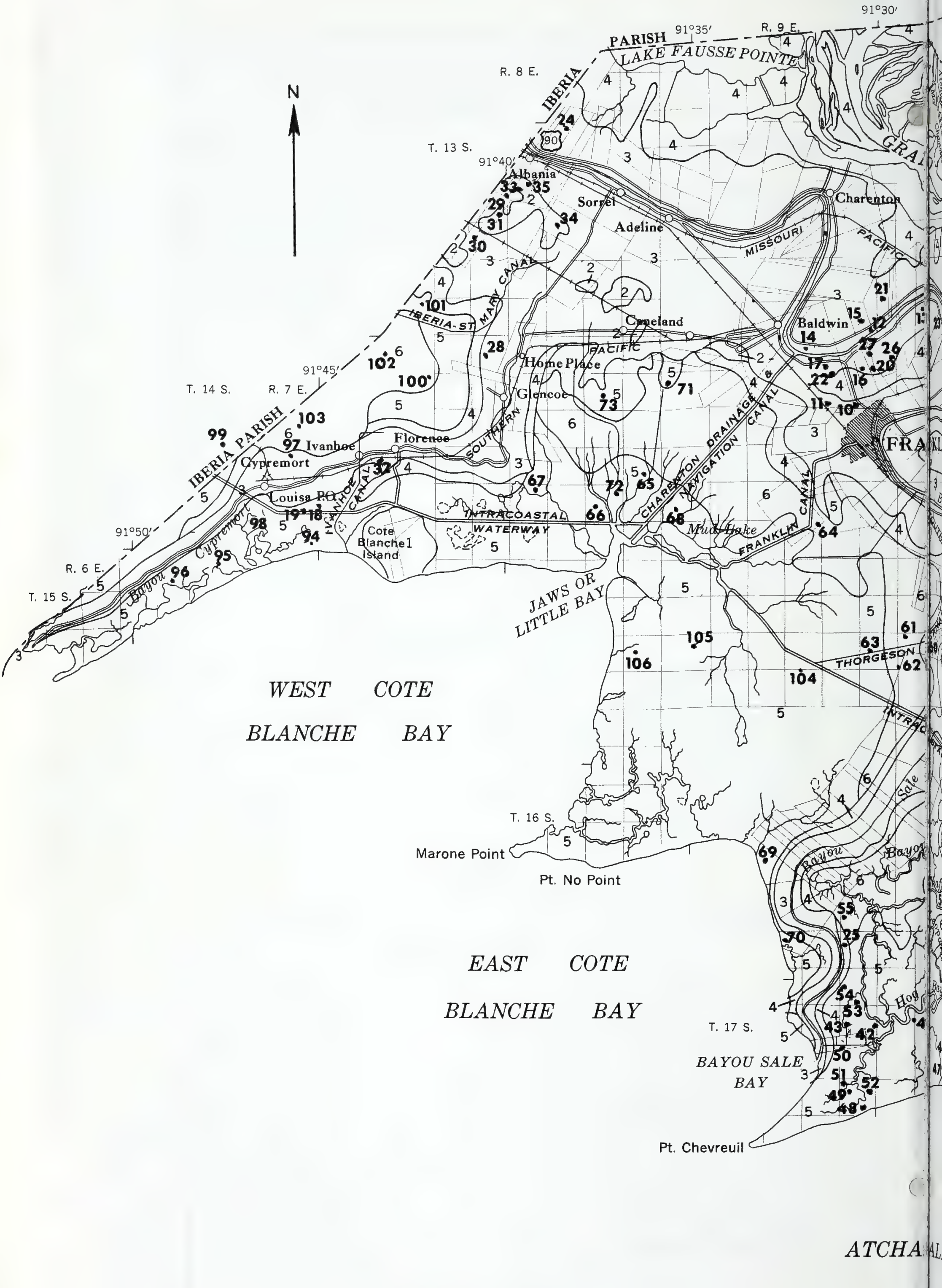
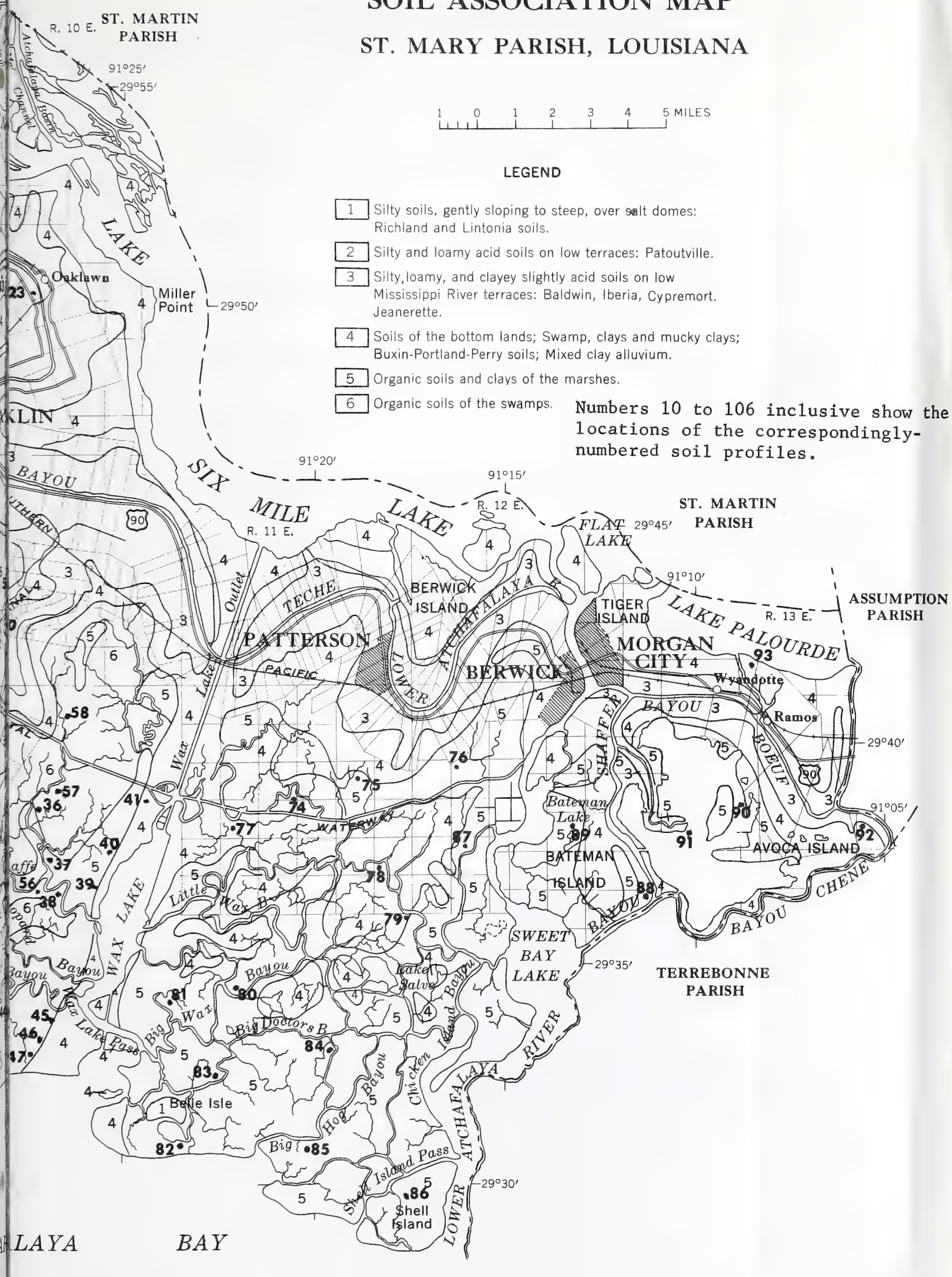
[1] Italic numbers in parentheses refer to Literature Cited, page 92.

Table 1.-Vegetation of the coastal marshlands and swamps of St. Mary Parish.

Botanical Name	Common Name
GRASSES	
Distichlis spicata	saltgrass, salt marshgrass
Panicum hemitomon	paille fine, maiden cane
Panicum virgatum	switchgrass, feathergrass
Phragmites comminus	common reed, roseau
Spartina cynosuroides	big cordgrass, quill cane
Spartina patens	couchgrass, marsh hay
Zizaniopsis miliacea	cutgrass , water millet
FORBS	
Alternanthera philoxeroides	alligator weed
Eichhornia crassipes	water hyacinth
Hibiscus lasiocarpos	rose-mallow
Juncus effusus	common rush, soft rush
Juncus roemerianus	black rush, needlegrass
Pontederia cordata	pickerelweed
Sagittaria lancifolia	delta potato, bull tongue
Saururus cernuus	lizard's tail
Typha latifolia	cattail
FORBS-SEDGES	
Dichromena colorata	star sedge, star rush
Eleocharis parvula	spike sedge
Mariscus jamaicenis	sawgrass
Rhynchospora corniculata	beak rush, horned rush
Scirpus californicus	giant bulrush
Scirpus olneyi	triangle sedge, three square
Scirpus robustus	leafy three square
Scirpus validus	bulrush, soft-stem bulrush
LEGUMES	
Vigna repens	wild cowpea
WOODY PLANTS	
Acer drummondii	swamp maple
Baccharis halimifolia	groundsel tree, marsh elder
Carya aquatica	water hickory
Celtis laevigata	hackberry
Cephalanthus occidentalis	button bush
Fraxinus tomentosa	pumpkin ash
Iva frutescens	buckbrush, marsh elder
Myrica cerifera	waxmyrtle
Nyssa aquatica	tupelogum
Quercus virginiana	liveoak
Salix nigra	black willow
Taxodium distichum	baldcypress


N
IBERIA PARISH
LAKE FAUSSE POINTE
91°35′
R. 9 E.
91°30′
R. 8 E.
T. 13 S.
91°40′
90
Albania
Sorrel
Adeline
Charenton
MISSOURI
PACIFIC
Baldwin
Caneland
PACIFIC
IBERIA-ST. MARY CANAL
Home Place
Glencoe
SOUTHERN
91°45′
T. 14 S.
R. 7 E.
Ivanhoe
Florence
Cypremort
Louisa P.O.
IVANHOE CANAL
Cote Blanche Island
INTRACOASTAL WATERWAY
CHARENTON DRAINAGE & NAVIGATION CANAL
Mud Lake
FRANKLIN CANAL
91°50′
R. 6 E.
T. 15 S.
Bayou Cypremort
JAWS OR LITTLE BAY
THORGESON
INTRACOASTAL
WEST COTE BLANCHE BAY
T. 16 S.
Marone Point
Pt. No Point
EAST COTE BLANCHE BAY
T. 17 S.
BAYOU SALE BAY
Pt. Chevreuil
Bayou Sale
Hog
ATCHA
FRA
GRA



SOIL ASSOCIATION MAP

ST. MARY PARISH, LOUISIANA

1 0 1 2 3 4 5 MILES

LEGEND

1	Silty soils, gently sloping to steep, over salt domes: Richland and Lintonia soils.
2	Silty and loamy acid soils on low terraces: Patoutville.
3	Silty, loamy, and clayey slightly acid soils on low Mississippi River terraces: Baldwin, Iberia, Cypremort, Jeanerette.
4	Soils of the bottom lands; Swamp, clays and mucky clays; Buxin-Portland-Perry soils; Mixed clay alluvium.
5	Organic soils and clays of the marshes.
6	Organic soils of the swamps.

Numbers 10 to 106 inclusive show the locations of the correspondingly-numbered soil profiles.

DESCRIPTIONS OF THE ORGANIC SOILS AND CLAYS OF THE COASTAL MARSHLANDS AND SWAMPS AND THEIR CHEMICAL AND MINERALOGICAL CHARACTERISTICS

FRESH WATER MARSH PEATS AND MUCKS

Soil Profile No. 42. Fresh Water Marsh Mucky Peat

Sample collected 2 miles northeast of the intersection of State Highway No. 317 and Bayou Sale Bay; Sec. 14, T.17 S., R.9 E., St. Mary Parish.

0-24"	Very dark brown (10YR 2/2)* mucky peat containing dark brown (10YR 4/3) coarse fibrous plant parts.
24-132"	Dark gray (10YR 4/1) clay.
132-140"	Gray (10YR 6/1) clay.

Dominant Vegetation: paille fine, with sawgrass.

Soil Profile No. 43. Fresh Water Marsh Mucky Peat

Sample site 1½ miles east-northeast of the intersection of State Highway No. 317 and Bayou Sale Bay; Sec. 14, T.17 S., R.9 E., St. Mary Parish.

0-108"	Dark brown (10YR 4/3) fine and coarse fibrous mucky peat.
108-130"	Dark gray (10YR 4/1) mucky clay.

Dominant Vegetation: paille fine and delta potato, with couchgrass, common reed, spike sedge and soft rush.

Soil Profile No. 53. Fresh Water Marsh Mucky Peat

Sampled 2 miles east of Salt Point; Sec. 11, T.17 S., R.9 E., St. Mary Parish.

0-60"	Dark brown (10YR 4/3) coarse fibrous mucky peat.
60-72"	Dark gray (5Y 4/1) clay.

Dominant Vegetation: paille fine 24 inches tall and feathergrass 36 inches tall, with couchgrass 36 inches tall and soft rush 48 inches tall.

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*Munsell color notation of the wet soil materials.

Soil Profile No. 55. Fresh Water Marsh Muck

Sampled 3 miles northeast of Salt Point; Sec. 2, T.17 S., R.9 E., St. Mary Parish.

0-48"	Black (5Y 2/1) muck.
48-60"	Dark gray (5Y 4/1) mucky clay.

Dominant Vegetation: cattail and feathergrass 5 feet tall, with big cordgrass 4 feet tall.

Soil Profile No. 60. Fresh Water Marsh Peaty Muck

Sample location 3 miles southwest of Bayou Sale station; Sec. 20, T.15 S., R.10 E., St. Mary Parish.

0-36"	Very dark brown (10YR 2/2) peaty muck.
36-72"	Dark gray (5Y 4/1) clay.

Dominant Vegetation: delta potato and big cordgrass 36 inches tall.

Soil Profile No. 63. Fresh Water Marsh Mucky Peat

Sampled 1½ miles northeast of the intersection of Thorgeson Canal and the Intracoastal Waterway; Sec. 25, T.15 S., R.9 E., St. Mary Parish.

0-36"	Dark brown (10YR 4/3) fibrous mucky peat.
36-84"	Dark brown (10YR 4/3) fine fibrous mucky peat.

Dominant Vegetation: cattail 6 feet tall, with delta potato and big cordgrass 3 feet tall.

Soil Profile No. 72. Fresh Water Marsh Peaty Muck

Samples collected 1½ miles north of Little Bay; Sec. 1, T.15 S., R.8 E., St. Mary Parish.

0-84"	Black (5Y 2/1) fine and coarse fibrous peaty muck.
84-108"	Dark gray (5Y 4/1) clay.

Dominant Vegetation: cutgrass 48 inches tall and delta potato 24 inches tall, with big cordgrass 48 inches tall.

Soil Profile No. 104. Fresh Water Marsh Peat

Sampled in the northeastern part of Sec. 34, T.15 S., R.9 E., St. Mary Parish.

0-96"	Very dark brown (10YR 2/2) fine and coarse fibrous peat.
96-108"	Black (5Y 2/1) mucky clay.

Dominant Vegetation: sawgrass and paille fine, with rose-mallow and couchgrass.

Soil Profile No. 106. Fresh Water Marsh Muck

Sampled from Sec. 25, T.15 S., R.8 E., St. Mary Parish.

0-36"	Black (10YR 2/1) muck.
36-108"	Very dark brown (10YR 2/2) muck.

Dominant Vegetation: couchgrass 18 inches tall, with spike sedge and delta potato 24 inches tall.

Chemical Characteristics of the Fresh Water Marsh Peats and Mucks of St. Mary Parish, Louisiana.

						Water Soluble Cations, Anions and Salts					
Soil Profile Number	Depth, Inches	pH	Organic Matter %	N %	C/N Ratio	Ca	K	Na	Cl	NaCl %	Total Salts %
						ppm					
42	0-24	5.6	29.89	1.12	15.51	290	130	640	540	.09	.38
	24-132	4.6	5.71	.20	16.88	220	170	1350	530	.09	.72
43	0-108	5.1	33.08	1.12	17.10	140	240	2860	3190	.53	1.27
	108-130	5.3	12.65	.43	17.11	460	270	3430	4340	.72	1.32
53	0-60	5.0	42.34	1.52	16.11	480	170	1660	1640	.27	1.16
	60-72	5.1	6.49	.22	17.20	190	130	1600	1230	.20	.78
55	0-48	4.9	30.76	1.07	16.99	520	170	2030	1750	.29	1.14
	48-60	4.1	12.45	.31	22.97	690	170	1820	960	.16	1.34
60	0-36	5.0	29.71	1.19	14.54	370	40	880	1370	.23	.35
	36-72	5.5	4.47	.19	13.50	20		260	350	.06	.06
63	0-36	5.0	47.69	1.66	16.60	900	60	620	780	.13	.84
	36-84	5.1	86.98	1.81	27.80						
72	0-84	5.3	31.22	1.05	17.31	70	160	1660	1680	.28	.75
	84-108	5.8	5.59	.15	21.22	20	130	1860	1480	.24	.59
104	0-96	4.4	50.11	1.47	19.66						
	96-108	4.1	14.04	.31	26.39	760	210	3150	2900	.48	1.75
106	0-36	4.8	40.60	1.33	17.74	440	150	2000		.36	1.15
	36-108	4.8	82.27	1.66	28.76						

FRESH WATER MARSH SILTY MUCKS AND CLAYEY MUCKS

Soil Profile No. 38. Fresh Water Marsh Clayey Muck

Sampled near Bayou Blue; 4 miles south of the Intracoastal Waterway; T.16 S., R.10 E., St. Mary Parish.

0-138"	Black (5YR 2/1) clayey muck.
138-144"	Dark brown (10YR 4/3) fine and coarse fibrous peat.

Dominant Vegetation: delta potato, paille fine and common reed.

Soil Profile No. 39. Fresh Water Marsh Silty Muck

Sample site 1 mile north of the confluence of Bayou Blue and Wax Lake; T.16 S., R.10 E., St. Mary Parish.

0-48"	Black (5Y 2/1) silty muck.
48-138"	Dark gray (5Y 4/1) clay.

Dominant Vegetation: paille fine and delta potato, with saltgrass and triangle sedge.

Soil Profile No. 40. Fresh Water Marsh Silty Muck

Sample location 2 miles north of the confluence of Bayou Blue and Wax Lake; eastern part of T.16 S., R.10 E., St. Mary Parish.

0-48"	Black (5Y 2/1) silty muck.
48-138"	Gray (10YR 6/1) clay.

Dominant Vegetation: cattail, sawgrass and common reed.

Soil Profile No. 44. Fresh Water Marsh Silty Muck

Sample site near Hog Bayou; northeastern part of Sec. 13, T.17 S., R.9E., St. Mary Parish.

0-36"	Dark brown (10YR 4/3) fine fibrous silty muck.
36-108"	Black (5Y 2/1) clay.

Dominant Vegetation: paille fine and common reed, with leafy three-square.

Soil Profile No. 50. Fresh Water Marsh Silty Muck

Sample site 2 miles southeast of Salt Point; Sec. 37, T.17 S., R.9 E., St. Mary Parish.

0-84"	Black (5Y 2/1) silty muck.
84-132"	Dark gray (5Y 4/1) clay.

Dominant Vegetation: cattail and soft-stem bulrush, with big cordgrass.

Soil Profile No. 52. Fresh Water Marsh Silty Muck

Sampled from the east side of Horseshoe Bayou; ½ mile north of Atchafalaya Bay; Sec. 26, T.17 S., R.9 E., St. Mary Parish.

0-120"	Black (5Y 2/1) silty muck.
120-130"	Dark gray (5Y 4/1) clay.

Dominant Vegetation: bulrush 8 feet tall, with delta potato.

Soil Profile No. 54. Fresh Water Marsh Silty Muck

Sample site 1½ miles north of Salt Point; Sec. 11, T.17 S., R.9 E., St. Mary Parish.

0-48"	Very dark brown (10YR 2/2) silty muck containing 20 per cent coarse fibrous plant materials.
48-60"	Dark gray (5Y 4/1) clay.

Dominant Vegetation: delta potato 36 inches tall, with feathergrass 48 inches tall and triangle sedge 36 inches tall.

Soil Profile No. 56. Fresh Water Marsh Silty Muck

Sample site 100 feet south of Bayou Chaffe; southern part of T.16 S., R.10 E., St. Mary Parish.

0-72"	Very dark grayish-brown (10YR 3/2) silty muck.
72-84"	Very dark gray (10YR 3/1) clay.

Dominant Vegetation: delta potato, with big cordgrass and triangle sedge.

Soil Profile No. 58. Fresh Water Marsh Clayey Muck

Sampled near Bayou Blue; Sec. 59, T.15 S., R.10 E., St. Mary Parish.

0-72"	Black (10YR 2/1) clayey muck.
72-96"	Black mucky clay.

Dominant Vegetation: cattail, with feathergrass and big cordgrass.

Soil Profile No. 75. Fresh Water Marsh Silty Muck

Sampled in Sec. 14, T.16 S., R.11 E., St. Mary Parish.

0-60"	Very dark grayish-brown (10YR 3/2) silty muck.
60-72"	Very dark gray (5Y 3/1) clay.

Dominant Vegetation: paille fine 4 feet tall, with delta potato 3 feet tall, big cordgrass 8 feet tall and spike sedge 3 feet tall.

Soil Profile No. 76. Fresh Water Marsh Silty Muck

Sample site 200 feet north of Intracoastal Waterway; Sec. 17, T.16 S., R.12 E., St. Mary Parish.

0-60"	Very dark grayish-brown (10YR 3/2) silty muck containing 20 per cent coarse fibrous plant parts.
60-80"	Dark gray (10YR 4/1) clay.

Dominant Vegetation: paille fine 5 feet tall, with big cordgrass 6 feet tall and couchgrass 3 feet tall.

Soil Profile No. 78. Fresh Water Marsh Silty Muck

Samples collected 100 feet south of Bull Bayou; Sec. 27, T.16 S., R.11 E., St. Mary Parish.

0-96"	Very dark grayish-brown (10YR 3/2) silty muck.
96-108"	Black (10YR 2/1) clay.

Dominant Vegetation: paille fine 4 feet tall, with cutgrass 6 feet tall and big cordgrass 5 feet tall.

Soil Profile No. 88. Fresh Water Marsh Silty Muck

Sampled from Bateman Island; Sec. 11, T.17 S., R.12 E., St. Mary Parish.

0-12"	Very dark brown (10YR 2/2) silty muck, containing 15 per cent coarse fibrous plant parts.
12-108"	Dark gray (10YR 4/1) clay.

Dominant Vegetation: cutgrass 7 feet tall, with delta potato and pickerelweed 2 feet tall.

Soil Profile No. 89. Fresh Water Marsh Clayey Muck

Sampled from Bateman Island; Sec. 34, T.16 S., R.12 E., St. Mary Parish.

0-12"	Very dark brown (10YR 2/2) clayey muck.
12-108"	Dark gray (10YR 4/1) clay.

Dominant Vegetation: cattail 7 feet tall, delta potato and pickerelweed 2 feet tall, with button bush, swamp maple and ash trees.

Soil Profile No. 90. Fresh Water Marsh Clayey Muck

Sampled below 2 feet of water in lake on Avoca Island; Sec. 32, T.16 S., R.13 E., St. Mary Parish.

0-24"	Water.
24-60"	Very dark gray (10YR 3/1) clayey muck.
60-84"	Black (10YR 2/1) clayey muck.

Dominant Vegetation: few cypress trees and floating water hyacinths.

Soil Profile No. 91. Fresh Water Marsh Clayey Muck

Sampled below 3 feet of water in lake on Avoca Island; Sec. 6, T.17 S., R.13 E., St. Mary Parish.

0-36"	Water.
36-72"	Black (10YR 2/1) clayey muck.

No Vegetation.

Soil Profile No. 98. Fresh Water Marsh Clayey Muck

Sampled 1 mile southeast of Louisa Post Office; T.15 S., R.7 E., St. Mary Parish.

0-12"	Very dark grayish-brown (10YR 3/2) clayey muck.
12-48"	Dark gray (10YR 4/1) clay with thin (2 to 4 inch) lenses of sandy loam.

Dominant Vegetation: giant bulrush and cutgrass, with big cordgrass.

Chemical Characteristics of the Fresh Water Marsh Silty Mucks and Clayey Mucks of St. Mary Parish, Louisiana.

						Water Soluble Cations, Anions and Salts					
Soil Profile Number	Depth Inches	pH	Organic Matter %	N %	C/N Ratio	Ca	K	Na	Cl	NaCl %	Total Salts %
						ppm					
38	0-138	4.9	16.42	.56	17.15						
39	0-48	5.7	18.49	.69	15.53	40	120	1020	870	.14	.44
	48-138	4.9	6.35	.20	18.15						
40	0-48	4.9	19.01	.75	14.63	820	100	810	880	.15	.78
	48-138	5.2	4.81	.18	15.42	360	210	2070	1800	.30	.84
44	0-36	4.4	18.00	.66	15.72	890	120	630	430	.07	.96
	36-108	3.4	7.38	.21	20.16	980	170	1870	1340	.18	1.56
50	0-84	3.5	19.70	.76	15.08	1140	130	1110	890	.15	1.46
	84-132	3.8	8.05	.26	17.70	1060	160	1290	950	.16	1.38
52	0-120	3.3	18.44	.68	15.77	1380	60	1170	940	.16	1.58
	120-130	3.0	8.72	.24	21.02	890	160	1850	1590	.26	1.73
54	0-48	3.6	25.38	.83	17.78	1600	120	1390	850	.14	1.92
	48-60	3.2	5.93	.20	17.21	830	100	1080	480	.08	1.22
56	0-72	4.2	19.62	.78	14.59						
	72-84	4.7	6.49	.27	13.98	100	210	2370	2920	.48	.73
58	0-72	4.7	16.27	.67	14.17	470	30	380	370	.06	.45
	72-96	3.3	9.92	.28	20.90	970	80	740	430	.07	1.49
75	0-60	5.0	26.82	.97	16.91	940	80	700	650	.11	.83
	60-72	3.2	6.56	.17	21.87	880	100	1130	650	.11	1.29

(Continued)

Chemical Characteristics of the Fresh Water Marsh Silty Mucks and Clayey Mucks of St. Mary Parish, Louisiana.

(Continued)

						Water Soluble Cations			Anions and Salts		
Soil Profile Number	Depth Inches	pH	Organic Matter %	N %	C/N Ratio	Ca	K	Na	Cl	NaCl %	Total Salts %
						ppm					
76	0-60	4.3	22.37	.80	16.60	1300	100	700	610	.10	1.12
	60-80	4.3	6.00	.18	19.41	390	120	1080	540	.09	.67
78	0-96	4.3	20.30	.74	16.00	1140	90	780	1000	.17	1.05
	96-108	4.5	8.99	.29	17.80	350	270	2320	2330	.38	1.11
88	0-12	5.2	18.44	.78	12.75	180	40	350	340	.06	.21
	12-108	5.4	5.72	.24	14.01	70	70	540	380	.06	.20
89	0-48	5.7	15.44	.58	15.48	370	60	720	480	.08	.42
	48-96	6.4	6.15	.22	16.34	80	90	1120	950	.16	.36
90	0-60	4.1	21.02	.67	18.10	1020	240	1780	1400	.23	1.60
91	0-72	4.9	24.21	.78	18.08	580	220	2210	1500	.25	1.46
98	0-12	4.8	18.05	.73	14.27	30	160	1950	2350	.39	1.01
	12-48	6.5	6.5	.08	20.66		40	710	430	.07	.19

FRESH WATER MARSH MUCKY SILTY CLAYS AND MUCKY CLAYS

Soil Profile No. 37. Fresh Water Marsh Mucky Silty Clay

Sample site 2 miles northwest of the confluence of Bayou Blue and Wax Lake; south-central part of T.16 S., R.10 E., St. Mary Parish.

0-48"	Dark grayish-brown (10YR 4/2) coarse fibrous mucky silty clay.
48-96"	Gray (10YR 6/1) clay.

Dominant Vegetation: cattail, common reed, paille fine, with couchgrass and spike sedge.

Soil Profile No. 48. Fresh Water Marsh Mucky Clay

Sampled 1/10 mile north of Atchafalaya Bay, and 3½ miles northeast of Point Chevreuil; southwestern part of Sec. 26, T.17 S., R.9 E., St. Mary Parish.

0-60"	Dark brown (10YR 4/3) mucky clay.
60-72"	Dark gray (10YR 4/1) clay.

Dominant Vegetation: cattail and common reed.

Soil Profile No. 51. Fresh Water Marsh Mucky Silty Clay

Sample site 3½ miles northeast of Point Chevreuil; Sec. 40, T.17 S., R.9 E., St. Mary Parish.

0-120"	Very dark gray (10YR 3/1) mucky silty clay.
120-126"	Light gray (10YR 7/1) clay.

Dominant Vegetation: paille fine 4 feet tall, with couchgrass 3 feet tall, spike sedge 2 feet tall and common reed 10 feet tall.

Soil Profile No. 80. Fresh Water Marsh Mucky Silty Clay

Sample site near Wax Bayou; Sec. 8, T.17 S., R.11 E., St. Mary Parish.

0-48"	Very dark grayish brown (10YR 3/2) mucky silty clay with coarse roots and parts of plants.
48-84"	Black (10YR 2/1) mucky clay.
84-96"	Light gray (10YR 7/1) clay.

Dominant Vegetation: along the bayou: common reed 8 feet tall. In the marshes: big cordgrass 5 feet tall, delta potato 3 feet tall, cattail 8 feet tall and paille fine 3 feet tall.

Soil Profile No. 81. Fresh Water Marsh Mucky Silty Clay

Sample site near Six Mile Bayou; Sec. 13, T.17 S., R.10 E., St. Mary Parish.

0-6"	Dark grayish-brown (10YR 4/2) mucky silty clay.
6-30"	Dark gray (10YR 4/1) mucky clay.
30-48"	Gray (10YR 6/1) clay.

Dominant Vegetation: cutgrass 4 feet tall, with big cordgrass 5 to 8 feet tall, alligator weed and wild cowpea.

Soil Profile No. 86. Fresh Water Marsh Mucky Silty Clay

Sample site in the central part of Shell Island; southeastern part of Sec. 12, T.18 S., R.11 E., St. Mary Parish.

0-24"	Very dark grayish-brown (10YR 3/2) mucky silty clay.
24-108"	Gray (10YR 6/1) soft, oozy clay.

Dominant Vegetation: cattail 8 feet tall, common reed 10 feet tall and cutgrass 4 feet tall.

Soil Profile No. 87. Fresh Water Marsh Mucky Silty Clay

Sample site 5 miles southeast of Patterson; northwestern part of Sec. 29, T.16 S., R.12 E., St. Mary Parish.

0-18"	Very dark brown (10YR 2/2) mucky silty clay.
18-102"	Dark gray (10YR 4/1) mucky clay.

Dominant Vegetation: cutgrass 4 to 5 feet tall, with cattail 10 to 12 feet tall.

Soil Profile No. 97. Fresh Water Marsh Mucky Silty Clay

Sample site 1 4/10 miles northeast of Louisa Post Office; southeastern part of T.14 S., R.7 E., St. Mary Parish.

0-96"	Very dark grayish-brown (10YR 3/2) mucky silty clay with thin (2 to 4 inch) lenses of very fine sandy loam.
96-108"	Gray (10YR 5/1) clay.

Dominant Vegetation: cattail 8 feet tall, cutgrass 3 feet tall and wild cowpea, with couchgrass 18 inches tall and big cordgrass 6 feet tall.

Chemical Characteristics of the Fresh Water Marsh Mucky Clays and Mucky Silty Clays of St. Mary Parish, Louisiana.

						Water Soluble Cations, Anions and Salts					
Soil Profile Number	Depth Inches	pH	Organic Matter %	N %	C/N Ratio	Ca	K	Na	Cl	NaCl %	Total Salts %
						------------ppm-------------					
37	0-48	4.5	11.44	.41	16.14	1070	220	1290	1330	.22	1.12
48	0-60	3.2	13.80	.53	15.01						
	60-72	3.8	4.92	.15	18.56	490	230	1830	1460	.24	1.04
51	0-120	3.8	15.47	.56	16.10	650	190	1900	1080	.18	1.27
	120-126	3.8	6.35	.20	19.35	540	200	1870	1190	.20	1.22
80	0-48	4.2	13.71	.58	13.74	1080	60	390	310	.05	.83
	48-84	4.4	12.09	.40	17.57	520	300	2580	2720	.45	1.23
81	0-6	4.9	10.90	.54	11.72	40	20	230	210	.04	.12
	6-30	4.4	6.57	.29	13.14	250	90	770	590	.10	.47
86	0-24	4.3	11.18	.48	13.41	700	80	1440	1200	.43	.70
	24-108	6.2	7.49	.28	15.29	250	180	1880	2600	.10	.40
87	0-18	5.2	11.27	.48	13.50	440	50	610	600	.10	.40
	18-102	6.0	12.70	.49	15.13	330	110	1720	1780	.29	.70
97	0-96	5.5	14.58	.59	14.84	310	220	1030	1370	.23	.37
	96-108	6.1	5.98	.24	14.45	270	250	790	900	.15	.22

FRESH WATER MARSH CLAYS

Soil Profile No. 41. Fresh Water Marsh Clay

Sample site northwest of Wax Lake and 1 mile south of the Intracoastal Waterway; east-central part of T.16 S., R.10 E., St. Mary Parish.

0-48"	Very dark gray (10YR 3/1) clay.
48-132"	Gray (10YR 5/1) mucky clay.

Dominant Vegetation: common reed and cattail.

Soil Profile No. 45. Fresh Water Marsh Clay

Sampled near Hog Bayou; 3/4 mile west of Wax Lake Pass, central part of T.17 S., R.10 E., St. Mary Parish.

0-48"	Dark gray (10YR 4/1) clay.
48-84"	Dark gray clay.

Dominant Vegetation: delta potato and common reed, with cattail, cutgrass and spike sedge.

Soil Profile No. 46. Fresh Water Marsh Clay

Sample site 1 mile north of Atchafalaya Bay and 2 miles northwest of Grass Island; west-central part of T.17 S., R.10 E., St. Mary Parish.

0-12"	Dark gray (10YR 4/1) clay.
12-108"	Gray (10YR 5/1) clay.

Dominant Vegetation: delta potato and common reed.

Soil Profile No. 47. Fresh Water Marsh Clay

Sampled 2½ miles northwest of Belle Isle Point and 2/10 mile north of Atchafalaya Bay; T.17 S., R.10 E., St. Mary Parish.

0-24"	Dark gray (10YR 4/1) clay.
24-40"	Light gray (10YR 7/1) clay stratified with sandy clay.
40-50"	Light gray (10YR 7/1) very fine sandy loam mottled with yellowish brown (10YR 5/6).

Dominant Vegetation: cattail and common reed.

Soil Profile No. 49. Fresh Water Marsh Clay

Sample site 100 feet from Horseshoe Bayou, and 7/10 mile north of Atchafalaya Bay; Sec. 23, T.17 S., R.9 E., St. Mary Parish.

0-24"	Very dark brown (10YR 2/2) clay overlain by 6 inches of coarse fibrous peaty muck.
24-84"	Gray (10YR 5/1) clay.

Dominant Vegetation: paille fine and giant bulrush, with couchgrass and triangle sedge.

Soil Profile No. 69. Fresh Water Marsh Clay

Sampled 2/10 mile east of East Cote Blanche Bay and ½ mile southwest of South Bend Cemetery; Sec. 16, T.16 S., R.9 E., St. Mary Parish.

0-12"	Very dark gray (10YR 3/1) clay.
12-48"	Gray (10YR 5/1) clay.

Dominant Vegetation: couchgrass 36 inches tall.

Soil Profile No. 70. Fresh Water Marsh Clay

Sample site 6 miles northeast of Point Chevreuil; Sec. 17, T.16 S., R.9 E., St. Mary Parish.

0-18"	Dark gray (10YR 4/1) mottled brown (10YR 5/3) clay.
18-42"	Gray (10YR 5/1) clay.
42-60"	Stratified gray silt loam and very fine sandy loam.

Dominant Vegetation: common rush 36 inches tall, with couchgrass 36 inches tall and spike sedge 6 inches tall.

Soil Profile No. 71. Fresh Water Marsh Clay

Sampled 3 miles southwest of Baldwin; Sec. 31, T.14 S., R.8 E., St. Mary Parish.

0-18"	Very dark grayish-brown (10YR 3/2) clay.
18-36"	Gray (10YR 5/1) clay.

Dominant Vegetation: cattail 8 feet tall and delta potato 2½ feet tall.

Soil Profile No. 83. Fresh Water Marsh Silty Clay

Sampled near Little Doctor's Bayou; Sec. 30, T.17 S., R.11 E., St. Mary Parish.

0-36"	Very dark grayish-brown (10YR 3/2) silty clay.
36-108"	Gray (10YR 5/1) clay.

Dominant Vegetation: delta potato 4 feet tall and paille fine 3 feet tall, with big cordgrass 6 feet tall and triangle sedge 4 feet tall.

Soil Profile No. 84. Fresh Water Marsh Clay

Sampled near Big Doctor's Bayou; 2½ miles south of Lake Salve; Sec. 22, T.17 S., R.11 E., St. Mary Parish.

0-12"	Very dark grayish brown (10YR 3/2) clay.
12-60"	Dark gray (10YR 4/1) clay.

Dominant Vegetation: common reed 12 feet tall and delta potato 3 feet tall, with big cordgrass 4 feet tall, giant bulrush 5 feet tall and triangle sedge 3 feet tall.

Soil Profile No. 85. Fresh Water Marsh Clay

Sampled 100 feet from Big Horn Bayou, Sec. 3, T.18 S., R.11 E., St. Mary Parish.

0-24"	Very dark grayish-brown (10YR 3/2) clay.
24-108"	Dark gray (10 YR 4/1) clay.

Dominant Vegetation: common reed 12 feet tall and delta potato 3 feet tall, with big cordgrass. Along the bayou: cutgrass, common reed and waxmyrtle with hackberry trees.

Soil Profile No. 95. Fresh Water Marsh Clay

Sample site 2 miles southeast of Louisa Post Office; T.15 S., R.7 E., St. Mary Parish.

0-84"	Very dark grayish-brown (10YR 3/2) clay.
84-108"	Gray (10YR 5/1) clay.

Dominant Vegetation: cutgrass, marsh elder and groundsel tree, with couchgrass and big cordgrass.

Chemical Characteristics of the Fresh Water Marsh Clays of St. Mary Parish, Louisiana.

						Water Soluble Cations, Anions and Salts					
Soil Profile Number	Depth Inches	pH	Organic Matter %	N %	C/N Ratio	Ca	K	Na	Cl	NaCl %	Total Salts %
						ppm					
41	0-48	5.6	6.09	.26	13.75	190	50	390	290	.05	.24
45	0-48	5.1	7.36	.33	13.02	360	50	360	210	.04	.39
	48-84	3.7	5.59	.20	16.05	490	330	3030	3190	.53	1.41
46	0-12	6.5	3.88	.17	13.33	540	110	2090	2440	.40	.91
	12-108	7.6	1.73	.06	15.85		130	1960	2450	.40	.51
47	0-24	6.6	2.41	.12	11.82		20	800	1050	.17	.17
	24-40	7.2	1.25	.08	9.40	10	20	830	1120	.18	.18
49	0-24	6.4	3.78	.16	13.31		100	1730	2340	.39	.39
	24-84	6.1	4.67	.22	12.05		110	2000	2700	.45	.45
69	0-12	5.0	8.98	.39	13.38	240	70	1320	1200	.20	.54
	12-48	6.1	3.41	.15	13.61		30	990	920	.15	.30
70	0-18	6.1	5.23	.26	11.86		20	680	650	.11	.16
	18-42	5.8	1.78	.07	15.22			490	500	.08	.08
71	0-10	5.6	8.36	.38	12.37			410	350	.06	.10
	18-36	5.5	3.91	.17	13.22			250	200	.03	.05
83	0-36	6.1	9.31	.45	11.92	120	20	190	170	.03	.09
	36-108	5.0	7.77	.31	14.37	310	140	1430	1310	.22	.63
84	0-12	5.7	8.45	.39	12.58	90	30	240	220	.04	.46
	12-60	4.8	7.32	.33	12.89	460	60	460	260	.04	.55
85	0-24	4.5	9.74	.41	13.76	710	230	320	250	.04	.55
	24-108	6.0	6.40	.21	17.78	170	50	1900	2000	.33	.76
95	0-84	5.3	6.61	.29	13.03		120	1430	1530	.25	.44
	84-108	5.7	1.61	.07	13.24		100	900	1450	.24	.28

BRACKISH MARSH PEATS AND MUCKS

Soil Profile No. 64. Brackish Marsh Peat

Sampled 2½ miles southwest of Franklin; southeastern part of Sec. 40, T.15 S., R.9 E., St. Mary Parish.

0-48"	Dark brown (10YR 4/3) fine and coarse fibrous peat.
48-60"	Dark gray (10YR 4/1) mucky clay.

Dominant Vegetation: big cordgrass, with paille fine and delta potato.

Soil Profile No. 65. Brackish Marsh Peaty Muck

Sampled 5 miles southwest of Baldwin; southeastern part of Sec. 44, T.14 S., R.8 E., St. Mary Parish.

0-108"	Very dark gray (10YR 3/1) peaty muck.
108-120"	Gray (10YR 6/1) clay.

Dominant Vegetation: big cordgrass, with cutgrass. Vegetation along the adjacent bayou includes common reed, paille fine, switchgrass, liveoak trees, waxmyrtle and marsh elder.

Soil Profile No. 66. Brackish Marsh Peaty Muck

Sampled 1 mile northeast of Hackberry Lake; Sec. 2, T.15 S., R.8 E., St. Mary Parish.

0-96"	Very dark gray (10YR 3/1) peaty muck.
96-108"	Dark gray (10YR 4/1) mucky clay.

Dominant Vegetation: couchgrass 24 inches tall, with cutgrass, big cordgrass, and paille fine.

Soil Profile No. 73. Brackish Marsh Peaty Muck

Sampled 4 miles southwest of Baldwin; northeastern part of Sec. 33, T.14 S., R.8 E., St. Mary Parish.

0-60"	Very dark brown (10YR 2/2) peaty muck.
60-72"	Dark gray (10YR 4/1) mucky clay.

Dominant Vegetation: cattail 8 feet tall, with sawgrass and delta potato 3 feet tall.

Soil Profile No. 99. *Brackish Marsh Peat*

Sampled 1½ miles northwest of Louisa Post Office; T.14 S., R.7 E., Iberia Parish.

0-96"	Dark brown (10YR 4/3) coarse fibrous peat.
96-108"	Black (10YR 2/1) mucky clay.

Dominant Vegetation: couchgrass, with big cordgrass.

Soil Profile No. 105. *Brackish Marsh Peat*

Sampled 7½ miles northeast of Marone Point; Sec. 30, T.15 S., R.9 E., St. Mary Parish.

0-96"	Dark brown (10YR 4/3) fine and coarse fibrous peat over woody materials.

Dominant Vegetation: couchgrass 14 inches tall and spike sedge 14 inches tall, with star sedge 18 inches tall, and three square and black rush 36 inches tall.

Chemical Characteristics of the Brackish Marsh Peats and Mucks of St. Mary Parish, Louisiana

Soil Profile Number	Depth Inches	pH	Organic Matter %	N %	C/N Ratio	Water Soluble Cations, Anions and Salts					
						Ca	K	Na	Cl	NaCl %	Total Salts %
						ppm	ppm	ppm	ppm		
64	0-48	5.5	76.32	2.25	19.67	50	140	3490	5460	.90	1.03
	48-60	6.0	10.38	.37	16.26						
65	0-108	4.4	27.40	.93	17.11	880	210	3800	4950	.82	1.70
66	0-96	5.4	28.98	.95	17.76	140	240	3560	5250	.87	1.37
	96-108	6.3	10.37	.27	21.96	370	240	5160	8430	1.39	1.60
73	0-60	5.2	38.22	1.40	15.88	60	130	3360	5560	.92	1.30
	60-72	5.0	12.77	.46	16.21	430	110	2150	2510	.41	.90
99	0-96	5.6	82.09	2.04	23.37	1180	360	10570	1370	3.21*	3.51
	96-108	5.5	15.78	.33	27.95	230	310	7120	900	1.67	2.22
105	0-96	5.7	68.06	1.95	20.27	840	310	8920	14990	2.48*	3.03

*
NaCl calculated on air-dry soil.
Brackish-marsh vegetation.

BRACKISH MARSH MUCKY CLAYS, CLAYEY MUCKS AND CLAYS

Soil Profile No. 67. Brackish Marsh Mucky Clay

Sampled 1¼ miles northwest of Hackberry Lake; Sec. 4, T.15 S., R.8 E., St. Mary Parish.

0-96"	Very dark gray (10YR 3/1) mucky clay.
96-108"	Very dark gray (10YR 3/1) clay.

Dominant Vegetation: big cordgrass, with couchgrass, common reed and paille fine.

Soil Profile No. 68. Brackish Marsh Clayey Muck

Sample site in the west-central part of Sec. 6, T.15 S., R.9 E., St. Mary Parish.

0-84"	Black (10YR 2/1) clayey muck containing 20 per cent coarse fibrous parts of plants.
85-96"	Very dark brown (10YR 2/2) peat.
96-108"	Gray (10YR 6/1) clay.

Dominant Vegetation: big cordgrass 6 feet tall and couchgrass 3 feet tall, with delta potato and spike sedge.

Soil Profile No. 82. Brackish Marsh Mucky Silty Clay

Sampled 1 mile south of Belle Isle; Sec. 1, T.18 S., R.10 E., St. Mary Parish.

0-24"	Very dark gray (10YR 3/1) mucky silty clay.
24-60"	Very dark gray mucky clay.

Dominant Vegetation: couchgrass 18 inches tall, with cattail 7 feet tall. Along the adjacent bayou: common reed, marsh elder and groundsel tree.

Soil Profile No. 94. Brackish Marsh Clay

Sample site 2 miles southeast of Louisa Post Office and 1/8 mile north of West Cote Blanche Bay, T.15 S., R.7 E., St. Mary Parish.

0-12"	Very dark grayish-brown (10YR 3/2) clay.
12-42"	Very dark gray (10YR 3/1) clay.

Dominant Vegetation: big cordgrass 5 feet tall and couchgrass 2 feet tall, with giant bulrush.

Soil Profile No. 96. Brackish Marsh Clayey Muck

Sampled 3 miles southwest of Louisa Post Office and 1 mile north of Cote Blanche Bay; T.15 S., R.6 E., St. Mary Parish.

0-72"	Black (10YR 2/1) clayey muck containing 20 per cent coarse fibrous peat.
72-108"	Gray (10YR 5/1) clay with lenses of gray silt.

Dominant Vegetation: triangle sedge 40 inches tall and couchgrass 24 inches tall, with beak rush 18 inches tall. Along the bayous the vegetation includes cattail, water hyacinth, alligator weed, delta potato, button bush, rose-mallow, marsh elder and groundsel tree.

Soil Profile No. 101. Brackish Marsh Clayey Muck

Sample site 3 miles northwest of headquarters of Home Place Plantation; T.14 S., R.7 E., St. Mary Parish.

0-36"	Very dark brown (10YR 2/2) clayey muck containing 20 per cent coarse fibrous peat.
36-42"	Dark gray (10YR 4/1) clay.

Dominant Vegetation: couchgrass and spike sedge 18 to 24 inches tall, with cattail 36 inches tall and delta potato 24 inches tall.

Chemical Characteristics of the Brackish Marsh Clayey Mucks,Mucky Clays and Clays of St. Mary Parish, Louisiana.

						Water Soluble Cations, Anions and Salts					
Soil Profile Number	Depth Inches	pH	Organic Matter %	N %	C/N Ratio	Ca	K	Na	Cl	NaCl %	Total Salts %
						ppm					
67	0-96	5.3	12.90	.53	14.06	360	140	2440	3180	.53	.59
	96-108	6.3	8.76	.28	18.17	350	170	4170	6700	1.11	1.39
68	0-84	5.5	20.81	.67	18.08	450	200	2810	4730	.78	1.04
82	0-24	4.4	14.34	.53	15.57	670	240	3030	3340	.55	1.55
	24-60	4.8	12.00	.43	16.20	1050	280	2830	3070	.51	1.84
94	0-12	6.4	5.05	.25	11.67	200	110	3150	5130	.85	.98
	12-42	6.2	4.83	.21	11.00	160	150	3200	5030	.83	.95
96	0-72	5.8	20.18	.71	16.39	210	270	3860	6350	1.05	1.23
	72-108	5.5	3.65	.14	15.38	140	170	2860	3740	.62	.97
101	0-36	5.2	24.17	.97	14.40	730	210	5770	10220	1.69	2.06
	36-42	5.7	4.73	.18	14.79	60	70	1760	2860	.47	.45

SWAMP MUCKY PEAT AND PEAT

Soil Profile No. 57. Swamp Mucky Peat

Sample site 100 feet east of Bayou Blue, and 1 mile south of the Intracoastal Waterway; 3 miles southeast of North Bend plantation headquarters; central part of T.16 S., R.10 E., St. Mary Parish.

0-24"	Dark brown (10YR 4/3) fibrous mucky peat.
24-48"	Dark gray (10YR 4/1) clayey muck.
48-72"	Dark gray clay.

Dominant Vegetation: swamp maple, willow and tupelogum trees, with an undergrowth of waxmyrtle, button bush, lizard's tail, delta potato and pickerelweed.

Soil Profile No. 61. Swamp Peat

Sampled 100 feet north of Thorgeson Canal; northeastern part of Sec. 25, T.15 S., R.9 E., St. Mary Parish.

0-48"	Dark brown (10YR 4/3) medium and coarse fibrous peat.
48-60"	Dark brown medium and coarse fibrous peat with parts of buried logs and stumps.

Dominant Vegetation: cypress and tupelogum trees.

Soil Profile No. 102. Swamp Peat

Sample site along Delahoussay Canal, 3 miles northwest of Richland Plantation headquarters, T.14 S., R.7 E., St. Mary Parish.

0-84"	Dark brown (10YR 4/3) medium and coarse fibrous peat.
84-108"	Dark gray (10YR 4/1) clay.

Dominant Vegetation: cypress and tupelogum trees, with willow and swamp maple.

Soil Profile No. 103. Swamp Peat

Sampled 1½ miles northeast of Louisa Post Office; T.14 S., R.7 E., St. Mary Parish.

0-60"	Dark brown (10YR 4/3) coarse fibrous peat.
60-72"	Dark gray (10YR 4/1) mucky clay.

Dominant Vegetation: swamp maple and willow trees with an undergrowth of waxmyrtle, rose-mallow and alligator weed.

Chemical Characteristics of the Swamp Mucky Peats and Peats of St. Mary Parish, Louisiana.

Soil Profile Number	Depth Inches	pH	Organic Matter %	N %	C/N Ratio	Water Soluble Cations, Anions and Salts					
						Ca	K	Na	Cl	NaCl	Total Salts
						ppm				%	%
57	0-24	4.6	32.28	1.09	17.10	820	120	1020	960	.16	.97
	24-48	3.8	15.46	.41	22.05	550	260	3030	2800	.46	1.87
61	0-48	5.0	53.08	1.74	17.68	380	70	530	600	.10	.46
	48-60	5.5	88.78	2.80	18.41	20	90	770	990	.16	.22
102	0-84	5.4	54.43	1.36	25.00	360	160	4560	8130	1.34	1.54
103	0-60	5.6	78.35	2.46	18.49	220	170	3960	6070	1.00	1.52
	60-72	5.8	13.48	.36	20.05	110	80	1430	2270	.38	.34

SWAMP SILTY MUCKS AND CLAYEY MUCKS

Soil Profile No. 59. Swamp Silty Muck

Sampled near Thorgeson Canal; 3½ miles north of the headquarters of North Bend plantation; southern part of Sec. 20, T.15 S., R.10 E., St. Mary Parish.

0-18"	Very dark grayish-brown (10YR 3/2) silty muck.
18-48"	Gray (10YR 5/1) clay.

Dominant Vegetation: cypress trees with an undergrowth of pickerelweed.

Soil Profile No. 62. Swamp Clayey Muck

Sample site 4 miles southwest of Bayou Sale Station, along Thorgeson Canal; Sec. 25, T.15 S., R.9 E., St. Mary Parish.

0-48"	Very dark brown (10YR 2/2) clayey muck containing 20 per cent coarse fibrous peat. Uncerlain by logs and stumps.

Dominant Vegetation: cypress and tupelogum trees.

Soil Profile No. 74. Swamp Clayey Muck

Sampled 100 feet from Possum Bayou; 3½ miles southeast of Calumet Plantation headquarters; southeastern part of Sec. 16, T.16 S., R.11 E., St. Mary Parish.

0-84"	Very dark grayish-brown (10YR 3/2) clayey muck.
84-108"	Dark brown (10YR 4/3) peat.

Dominant Vegetation: waxmyrtle and willow.

Soil Profile No. 77. Swamp Clayey Muck

Sample site 4½ miles south of Calumet Plantation headquarters, central part of Sec. 20, T.16 S., R.11 E., St. Mary Parish.

0-84"	Very dark brown (10YR 2/2) clayey muck.
84-96"	Dark gray (10YR 4/1) clay.

Dominant Vegetation: swamp maple and willow trees, with an undergrowth of waxmyrtle, pickerelweed, delta potato and lizard's tail.

Chemical Characteristics of the Swamp Silty Mucks and Clayey Mucks of St. Mary Parish, Louisiana.

Soil Profile Number	Depth Inches	pH	Organic Matter %	N %	C/N Ratio	Water Soluble Cations, Anions and Salts					
						Ca	K	Na	Cl	NaCl	Total Salts
						ppm				%	%
59	0-18	4.9	15.99	.61	15.25			280	350	.06	.09
	18-48	5.1	1.55	.07	12.49			140	130	.02	.03
62	0-48	5.6	20.93	.68	17.87	200	30	200	230	.04	.17
74	0-84	4.9	20.40	.72	16.40	830	70	340	320	.05	.62
	84-108	5.4	40.26	1.17	19.94						
77	0-84	4.7	20.45	.71	16.73	920	90	500	430	.07	.71
	84-96	5.1	9.77	.30	18.72	480	250	2070	1700	.28	1.09

SWAMP CLAYS AND MUCKY CLAYS

Soil Profile No. 36. Swamp Clay

Sample site near Bayou Blue; 3 miles northeast of North Bend Plantation headquarters; west-central part of T.16 S., R.10 E., St. Mary Parish.

0-96"	Dark gray (10YR 4/1) clay.
96-108"	Gray (10YR 5/1) silt loam.
108-144"	Dark gray (10YR 4/1) clay.

Dominant Vegetation: liveoak and willow trees with an undergrowth of palmetto and waxmyrtle.

Soil Profile No. 79. Swamp Clay

Sample site 100 feet west of Cross Bayou; 5½ miles south of Idlewild Plantation headquarters; northeast corner of T.17 S., R.11 E., St. Mary Parish.

0-12"	Dark gray (10YR 4/1) clay.
12-198"	Dark gray clay.

Dominant Vegetation: waxmyrtle and button bush, with a few cypress trees; an undergrowth of delta potato.

Soil Profile No. 92. Swamp Clay

Sample site 8 miles southeast of Morgan City; 200 feet south of Bayou Chene; southeastern part of Sec. 36, T.16 S., R.13 E., St. Mary Parish.

0-12"	Very dark grayish-brown (10YR 3/2) clay.
12-48"	Very dark gray (10YR 3/1) mucky clay.

Dominant Vegetation: cypress, tupelogum and willow trees with an undergrowth of lizard's tail.

Soil Profile No. 93. Swamp Mucky Clay

Sampled 3½ miles east-northeast of Morgan City and 200 feet south of Lake Palourde; Sec. 9, T.16 S., R.13 E., St. Mary Parish.

0-12"	Very dark grayish-brown (10YR 3/2) mucky clay.
12-48"	Dark gray (10YR 4/1) mucky clay.

Dominant Vegetation: swamp maple, tupelogum, willow, cypress and hickory trees.

Soil Profile No. 100. Swamp Mucky Clay

Sampled 1½ miles northwest of Home Place Plantation headquarters; central part of Sec. 24, T.14 S., R.8 E., St. Mary Parish.

0-24"	Very dark brown (10YR 2/2) mucky clay.
24-48"	Dark gray (10YR 4/1) clay.

Dominant Vegetation: tupelogum, swamp maple, cypress and willow trees with an undergrowth of cutgrass and lizard's tail.

Chemical Characteristics of the Swamp Clays and Mucky Clays of St. Mary Parish, Louisiana.

						Water Soluble Cations, Anions and Salts					
Soil Profile Number	Depth Inches	pH	Organic Matter %	N %	C/N Ratio	Ca	K	Na	Cl	NaCl %	Total Salts %
						ppm					
36	0-96	5.9	4.34	.19	13.36	20	70	400	230	.04	.11
79	0-12	5.2	6.10	.25	14.37	50	40	160	180	.03	.07
	12-108	6.1	5.87	.21	16.32	170	110	1320	1230	.20	.49
92	0-12	6.1	6.25	.28	13.02	20	10	150	160	.02	.06
	12-48	5.2	11.63	.43	15.84	100	40	220	190	.03	.15
93	0-12	5.3	13.10	.57	13.41	90	40	270	380	.06	.12
	12-48	6.1	9.43	.35	15.79	120	60	390	400	.07	.19
100	0-24	5.5	14.58	.59	14.84	110	70	1030	1370	.23	.37
	24-48	6.1	5.98	.24	14.45		40	790	900	.15	.22

Total Analysis of Selected Profiles of Coastal Marshland and Swamp Soils of St. Mary Parish, Louisiana.

Soil Profile Number	Depth, Inches	Classification	SiO_2	TiO_2	Fe_2O_3	Al_2O_3	MnO	CaO	MgO	K_2O	Na_2O	P_2O_5	SO_3	Cl	Ignition Loss
			per cent												
Fresh Water Marsh:															
47	0-24	Clay	74.29	.69	2.50	12.12	.04	.99	1.16	1.84	1.98	.25	.15	.28	4.36
	24-40	Clay	74.72	.72	2.65	12.49	.07	.96	1.20	1.88	1.84	.21	.28	.12	3.49
54	0-48	Silty muck	46.56	.65	4.23	13.38	.04	1.20	1.78	1.44	1.39	.21	1.68	.14	28.70
	48-60	Clay	63.10	.83	4.38	15.55	.03	.77	1.63	1.92	1.52	.19	2.98	.13	9.70
60	0-36	Peaty muck	48.79	.56	2.10	11.75	.03	.97	.97	.90	.92	.20	.49	.20	32.67
	36-72	Clay	69.68	.58	2.24	15.01	.03	.92	1.08	1.58	1.35	.14	.10	.03	7.57
Brackish Marsh:															
99	0-96	Peat	7.02	.12	.36	2.36	.02	1.89	1.81	.31	2.85	.07	5.63	2.24	80.58
	96-108	Mucky clay	49.20		5.06	17.48	.04	.95	2.43	2.22	2.28	.07	3.48	1.02	20.91
105	0-96	Peat	16.04	.03	1.37	5.95	.02	1.84	1.65	.86	2.48	.13	7.38	1.42	70.15
Swamp:															
61	0-48	Peat	30.30	.40	2.05	7.62	.04	1.67	.94	.91	.70	.23	.87	.07	55.27
	48-60	Peat	6.06	.07	.71	2.02	.02	1.20	.58	.13	.33	.26	.76	.19	87.91
103	0-60	Peat	11.14	.12	1.03	3.10	.02	1.51	1.03	.27	.92	.27	1.70	.70	80.45
	60-72	Mucky clay	53.64	.80	3.54	17.42	.03	.82	1.96	1.67	1.40	.16	.30	.23	18.48
59	0-18	Silty muck	59.86	.80	2.74	14.32	.05	.73	1.00	1.80	1.24	.15	.40	.07	19.33
	18-48	Clay	78.87	.82	1.74	12.36	.03	.57	.61	2.10	1.56	.05	.03	.03	3.40
62	0-48	Clayey muck	48.00	.86	3.91	16.42	.04	1.44	1.82	2.17	1.10	.16	.60	.07	24.97
92	0-12	Clay	60.21	.89	4.70	16.69	.08	1.14	1.93	2.04	1.19	.28	.21	.22	10.86
	12-48	Mucky clay	56.71	.83	4.41	16.16	.06	1.17	1.94	1.84	1.12	.27	.73	.05	15.67

Chemical Properties of the Soils Used for Farming

Soil Reaction

Soil reaction of the soils used for farming ranges from very strongly acid (pH 5.0) to moderately alkaline (pH 8.1). Soils of the Jeanerette, Iberia and Buxin series and the Baldwin silt loam, salty variant are slightly acid to moderately alkaline in reaction. The Patoutville and Cypremort soils range in reaction from very strongly acid to neutral. Soils of the Baldwin and Alligator series are strongly acid to neutral in reaction.

Base Saturation

The base saturation values are highest for the Jeanerette, Iberia and Buxin soils and the Baldwin silt loam, salty variant. Soils of the Cypremort and Patoutville series are lower in base saturation. These values are closely related to the calcium content and the pH.

Exchangeable Cations

Exchangeable calcium is relatively high in the Alligator, Buxin, Baldwin, Iberia and Jeanerette soils, with lower amounts in the Cypremort and Patoutville soils. The percentage of the total cation exchange capacity that is satisfied by each cation is given in Table 2. The exchangeable calcium is approximately 50 per cent of the total cation exchange capacity for all of the soils studied except the Patoutville soils.

Values for exchangeable magnesium are highest for profiles of the Alligator and Buxin soils and lowest for the Jeanerette, Patoutville and Cypremort soils and the Baldwin silt loam, salty variant. The percentage of the exchange complex satisfied by magnesium is approximately 30 per cent for all the soils except the Cypremort, Iberia and Patoutville. The ratio of exchangeable calcium to magnesium ranges from 1 to 1.7 for the Alligator and Buxin soils and Baldwin very fine sandy loam soils. The widest ratios are 6.5 for the Jeanerette soils and 4.7 for the Iberia soils. The ratios for the Patoutville, Cypremort and Baldwin silt loam soils range from 2 to 3.

The amounts of exchangeable potassium are highest in the clayey soils of the Alligator and Buxin series and in the clay-textured horizons of other soils. Lower amounts of exchangeable potassium are present in the Patoutville and Baldwin soils and in Baldwin silt loam, salty variant. The percentage of the exchange complex satisfied by potassium for most soils is approximately 2 per cent, with Jeanerette silt loam and Baldwin silt loam, salty variant having lower values of 0.6 to 1.3 per cent.

Values for exchangeable sodium are highest for all horizons of the Baldwin silt loam, salty variant and for substrata horizons of the Buxin, Baldwin and Patoutville soils. The Iberia and Jeanerette soils are low in exchangeable sodium. The percentage of the cation exchange capacity satisfied by sodium ranges from 2 to 3 per cent for most soils, with values of 4.0 to 6.6 per cent for Baldwin silt loam, salty variant.

Exchangeable acidity is highest in the Cypremort, Alligator and Bald-

Table 2.-Values for each exchangeable cation as per cent of the total cation exchange capacity for selected soil profiles.

Profile No. and Name	Soil Horizon	Depth, Inches	Percentage of the total CEC				
			Ca	Mg	K	Na	H
10. Alligator clay	Ap_1	0-2	52.1	33.2	1.5	1.4	12.4
	Ap_2	2-10	52.2	31.7	1.0	1.5	13.6
	C_{1g}	10-16	42.6	32.9	1.1	2.5	20.8
	C_{2g}	16-42	45.1	38.1	2.4	2.4	13.7
14. Buxin silty clay	Ap_1	0-7	46.6	37.6	2.9	1.6	11.2
	Ap_2	7-10	44.8	43.4	2.5	2.4	6.8
	C_1	10-18	45.6	44.0	2.4	3.1	4.7
	IIC_2	18-34	48.3	44.1	2.2	4.2	1.2
16. Baldwin silt loam	Ap_1	0-6	61.1	29.1	1.8	1.3	6.8
	Ap_2	6-9	51.3	29.0	1.7	1.8	16.2
	B_{2t}	9-24	50.2	31.2	1.8	2.4	14.3
	C	24-30	51.3	37.5	1.9	3.8	5.6
18. Baldwin silt loam, salty variant	Ap_1	0-6	64.0	25.7	.8	5.6	3.9
	Ap_2	6-14	64.0	26.1	.7	4.3	4.9
	A-C	14-22	62.0	28.7	.8	5.4	3.1
	C_1	22-30	59.7	29.8	.9	6.6	2.9
	C_2	30-38	59.7	34.2	1.3	3.5	1.2
	C_3	38-42	62.2	30.6	.9	3.5	3.0
20. Baldwin silt loam	Ap_1	0-5	51.0	25.3	2.2	1.0	20.3
	Ap_2	5-10	46.2	26.2	2.1	1.6	23.8
	B_{2t}	10-16	46.0	31.7	2.4	2.3	17.4
	B_3	16-30	49.6	34.4	2.1	2.9	11.0
23. Cypremort very fine sandy loam	Ap_1	0-4	45.8	15.2	3.0	1.7	34.3
	Ap_2	4-10	45.0	19.1	2.8	1.7	31.4
	B_{2t}	10-16	52.2	27.2	1.8	2.2	16.4
	B_3	16-24	55.2	27.6	1.6	3.7	11.9
	C_g	24-42	57.0	27.4	1.6	3.6	10.4
26. Iberia silty clay loam	Ap_1	0-7	74.2	15.9	2.2	1.3	6.3
	Ap_2	7-11	74.8	16.0	1.4	1.6	5.2
	B_{21t}	11-13	74.1	18.0	1.6	1.7	4.6
	B_{22t}	13-26	70.2	21.4	2.1	2.0	4.3
	C_g	23-40	67.2	23.4	2.4	2.0	4.9
30. Jeanerette silt loam	Ap	0-6	68.1	29.1	.7	2.2	
	B_{21t}	6-16	72.7	24.4	.6	2.4	
	B_{22t}	16-24	67.7	29.8	.7	1.7	
	C_1	24-30	66.7	29.9	.6	2.7	
	C_2	30-42	66.3	30.8	.6	2.3	
33. Patoutville very fine sandy loam	Ap_1	0-4	39.2	17.8	1.9	3.0	38.0
	Ap_2	4-12	39.2	19.0	2.4	2.4	37.0
	B_{21t}	12-20	34.4	35.6	1.6	3.5	25.0
	B_{22t}	20-30	33.8	45.0	2.1	4.1	15.0
	C	30-42	34.6	44.2	2.1	4.3	14.7

win soils and lowest in the Baldwin silt loam, salty variant and the Iberia, Jeanerette and Patoutville soils. There are wide variations in the percentages of the cation exchange capacity satisfied by hydrogen for the different horizons of each of the soils. The highest values are 15 to 38 per cent for Patoutville silt loam and 10 to 34 per cent for the Cypremort very fine sandy loam. The lowest values for percentages of the exchange capacity satisfied by hydrogen are 1 to 5 per cent for the Baldwin silt loam, salty variant and 4 to 6 per cent for Iberia silty clay loam. No values for extractable acidity were recorded for Jeanerette silt loam.

Total Bases and Exchangeable Bases

Values for total manganese oxide are highest in the Buxin and Baldwin soils and lowest in the Cypremort, Jeanerette, Iberia and Patoutville soils.

Total calcium oxide values are highest for the Jeanerette soil and lowest for the Baldwin, Buxin and Patoutville soils. The percentage of the total calcium on the exchange complex ranges from 45 to 76 per cent for the Buxin, Baldwin and Iberia soils. The lowest percentages of total calcium on the exchange complex are 2 to 34 per cent for the Cypremort, Jeanerette and Patoutville soils (Table 3).

Values for total magnesium oxide are highest in the Buxin, Baldwin and Cypremort soils and lowest in the Jeanerette and Patoutville soils. The percentages of the total magnesium on the exchange complex range from 10 to 31 per cent for the Baldwin, Iberia and Patoutville soils, and from 8 to 10 per cent for the Buxin, Cypremort and Jeanerette soils.

Total potassium oxide ranges from 1.4 to 2.3 per cent for the Buxin, Baldwin, Cypremort and Iberia soils and from 1.3 to 1.6 for the Jeanerette and Patoutville soils. The percentages of total potassium present as exchangeable potassium range from 1.0 to 2.4 for the Buxin, Baldwin and Cypremort soils and for profile number 26, Iberia silty clay loam, and from 0.35 to 0.92 for the Jeanerette and Patoutville soils and for profile number 28, Iberia silty clay loam.

The values for total sodium range from 1.3 to 1.95 per cent for all of the soils with the exception of Patoutville silt loam, which has the lowest values of 0.7 to 1.2 per cent. The percentage of the total sodium on the exchange complex varies between soil profiles and between soil horizons of all soil profiles. The highest values are 1.01 to 4.25 per cent for the horizons of Patoutville silt loam. The lowest values are 0.26 to 0.75 per cent for the horizons of Iberia silty clay. The other soils of this study have 0.53 to 2.12 per cent of the total sodium on the exchange complex. The sodium content increases with an increase in depth in the soil profile for most of the soils.

Total Analysis and Soil Profile Development

Interpretations about soil formation and soil profile development may be made from the total soil analysis data. The decrease in SiO_2 from the surface layers downward may be interpreted to indicate a removal of the fine clay fraction, leaving more particles of sand size. The Al_2O_3

Table 3.-The percentages of total bases in the soils that are present as exchangeable bases for selected soil profiles.

Profile No. and Name	Soil Horizon	Depth, Inches	Exchangeable bases divided by total bases			
			Ca	Mg	K	Na
			---------per cent-----------			
14. Buxin silty clay	Ap_1	0-7	57.4	10.0	1.76	.90
	Ap_2	7-10	55.6	11.5	1.66	1.41
	C_1	10-18	45.1	9.5	1.30	1.50
	IIC_2	18-34	36.0	11.9	1.03	1.24
16. Baldwin silt loam	Ap_1	0-6	50.4	17.1	1.60	.53
	Ap_2	6-9	71.3	28.7	2.36	1.42
	B_{2t}	9-24	69.8	31.0	2.16	1.90
	C	24-30	54.5	28.4	1.80	2.03
20. Baldwin silty clay loam	Ap_1	0-5	46.5	13.1	1.36	.46
	Ap_2	5-10	71.2	13.7	1.63	1.05
	B_{2t}	10-16	76.5	13.2	2.12	1.60
	B_3	16-30	63.9	14.2	1.56	1.59
23. Cypremort very fine sandy loam	Ap_1	0-4	23.3	7.0	1.05	.51
	Ap_2	4-10	27.5	8.1	1.04	.59
	B_{2t}	10-16	29.5	10.0	.86	.97
	B_3	16-24	75.7	8.6	.50	.93
	C_g	24-42	25.8	10.0	.58	1.01
26. Iberia silty clay loam	Ap_1	0-7	58.8	9.4	1.38	.75
	Ap_2	7-11	60.1	8.9	.86	.96
	B_{21t}	11-13	60.7	8.6	1.07	1.03
	B_{22t}	13-26	60.6	8.8	1.22	1.24
	C_g	26-40	46.7	8.3	1.28	1.07
28. Iberia silty clay	Ap_1	0-4	52.7	21.4	.35	.26
	Ap_2	4-10	56.3	23.4	.36	.36
	B_{21t}	10-22	64.0	20.8	.67	.60
	B_{22t}	22-28	62.4	17.7	.67	.75
	C	28-44	50.0	12.5	.51	.55
30. Jeanerette silt loam	Ap	0-6	7.2	8.1	.42	.93
	B_{21t}	6-16	5.5	10.1	.66	2.12
	B_{22t}	16-24	6.1	9.5	.59	1.01
	C_1	24-30	2.1	9.6	.41	1.39
34. Patoutville silt loam	Ap_1	0-4	27.0	15.1	.92	1.01
	Ap_2	4-7	27.0	11.4	.39	1.33
	B_{21t}	7-10	33.8	10.1	.48	1.84
	B_{22t}	10-22	31.0	13.7	.73	4.25
	B_3	22-36	32.8	12.7	.76	3.69
	C_g	36-48	20.9	13.5	.41	3.69

and Fe_2O_3 are components of the clay that has leached from the surface layer to accumulate in the soil profile at lower depths. Leaching of the soluble salts from upper soil horizons and their accumulation at lower depths in the soil is another indication of soil profile development.

The data obtained by total analysis show that profiles of the Baldwin, Cypremort, Iberia, Jeanerette and Patoutville soils each have a decrease in SiO_2 with depth, suggesting that some of the fine silt and clay have been leached out of the surface soils, leaving an appreciable amount of sand and sand-size particles. The amounts of Al_2O_3 and Fe_2O_3 increase in each of these soils with depth, which indicates that clays with their iron and alumina content are leached from the surface soil and accumulated in a lower horizon called the subsoil or B horizon. The increase in values between the surface soils and subsoils is not extreme, indicating that the soil profiles are weakly developed. Leaching of the soluble salts is another indicator of soil age and soil profile development. Most of the soils studied show some increases in MnO, CaO, MgO, K_2O and Na_2O contents from the surface soils to the subsoils.

The Baldwin, Cypremort, Iberia, Patoutville and Jeanerette series are considered to be weakly developed terrace soils. Soils of the Buxin and Alligator series and the Baldwin silt loam, salty variant do not exhibit properties that indicate illuvial clay accumulation, and they are considered to be alluvial soils.

Mineralogical Properties of the <2 Microns Clay

The X-ray analysis of the clay fraction indicates that the soils included in this study contain considerable amounts of montmorillonite and illite minerals and lesser amounts of kaolinite and quartz. Montmorillonite occurs as the dominant clay mineral, as shown in Table 4. Soil profiles number 21 of the Baldwin series and number 33 of the Patoutville series contain lower amounts of montmorillonite in all horizons than do soils of the Alligator, Buxin, Cypremort, Iberia and Jeanerette series and profile No. 16 of the Baldwin series.

The montmorillonite mineral content of the soils is reflected in the physical properties of the different soils and soil horizons.

Physical Properties of the Soils Used for Farming

The soils of St. Mary Parish are well supplied with most plant nutrients and organic matter, but the physical properties of the soils are important to the use and management of the soils used for farming. In this coastal area, major factors limiting the use of soils for cultivated crops are the elevation above sea level, soil texture and soil wetness. The slowly permeable soils of the Patoutville, Cypremort and Baldwin series typically occupy the natural levee areas at the highest elevations in the parish and they may be drained by the gravity flow of surface water in properly directed field rows. These soils have friable silt loam, very fine sandy loam and silty clay loam surface soils that are easy to work.

The clayey soils of the Alligator and Iberia series require special man-

Table 4.-The relative quantity of clay minerals* in selected soil horizons of representative soils of St. Mary Parish.

Profile No. and Name	Soil Horizon	CEC	Montmor-illonite	Illite	Kaolinite	Quartz
11. Alligator	Ap_2	48	> 40	10-40	10-40	< 10
	Ap_3	50	> 40	10-40	10-40	< 10
	C_g	49	> 40	10-40	10-40	< 10
14. Buxin	Ap_2	27	> 40	10-40	10-40	< 10
	C_1	25	> 40	10-40	10-40	< 10
	IIC_2	19	> 40	10-40	10-40	< 10
16. Baldwin	Ap_2	21	> 40	10-40	10-40	< 10
	B2t	34	> 40	10-40	10-40	< 10
	C	29	> 40	10-40	10-40	< 10
21. Baldwin	Ap_2	23	10-40	10-40	10-40	< 10
	B_{2t}	30	10-40	10-40	10-40	< 10
	C	27	10-40	10-40	10-40	< 10
25. Cypremort	Ap_2	22	> 40	10-40	10-40	< 10
	B_{2t}	23	> 40	10-40	10-40	< 10
	C	15	> 40	10-40	10-40	< 10
26. Iberia	Ap_2	25	> 40	10-40	10-40	< 10
	B_{22t}	25	> 40	10-40	10-40	< 10
	C_g		> 40	10-40	10-40	< 10
30. Jeanerette	Ap	14	> 40		10-40	< 10
	B_{22t}	19	> 40		10-40	< 10
	C_2	19	> 40	10-40	10-40	
33. Patoutville	Ap_2	9	10-40	10-40	10-40	< 10
	B_{21t}	16	> 40	10-40	10-40	< 10
	C	14	> 40	10-40	10-40	< 10

*Abundance of the minerals.

> 40 = greater than 40 per cent; most abundant

10-40 = 10 to 40 per cent

< 10 = less than 10 per cent; minor component

agement when used for crops. Seedbed preparation and other farming operations are difficult because of the plastic clay texture. Most areas of these soils which occur at elevations above 5 feet may be drained by ditches, with the water removed by gravity flow. Areas of Iberia and Alligator soils and narrow natural levees of Cypremort and Baldwin soils that occur at elevations of less than 5 feet require levees for protection from flooding and the use of pumps for removal of the surface water.

Most areas of Jeanerette soils are easily worked due to their friable silt loam texture. Jeanerette soils are usually not difficult to drain by open ditches since they commonly occur at elevations above 5 feet.

Soils of the Buxin series typically occupy the crests and stream-facing slopes of the natural levees. Most areas are effectively drained by directing the field furrows to provide gradient for the removal of the surface water.

Small amounts of phosphate and potassium fertilizers are used on some of the farming soils in St. Mary Parish, and nitrogen is generally applied to all crops. Most crops planted on the more acid soils of the Alligator, Cypremort, Baldwin and Patoutville series respond to application of limestone.

Chemical Properties of the Organic Soils and Clays of the Coastal Marshes and Swamps

The clayey sediments of the coastal marshlands and swamps are covered in many areas by a surface layer of organic materials ranging in thickness from less than 1 foot to more than 11 feet. Peat and muck layers ranging from 4 feet to more than 9 feet overlie the silty and clayey substrata in the areas of Fresh Water Marsh and Brackish Marsh. The Swamp peats and mucks have organic surface layers ranging from 2 to 7 feet thick over the clay substrata materials. Silty mucks and clayey mucks of the marshes and swamps have surface layers 7 to more than 11 feet thick which are high in organic materials. Some areas of mucky clays and clays have shallow surface layers of organic materials 6 inches to 2 feet in thickness.

The pH values of the marsh and swamp lands range from extremely acid (pH 3.2) to mildly alkaline (pH 7.6). The most acid soils are Fresh Water Marsh silty mucks and clayey mucks (pH 3.3 to 5.7), Fresh Water Marsh mucky clays (pH 3.2 to 5.5), Fresh Water Marsh peats and mucks (pH 4.4 to 5.6), and Brackish Marsh peats and mucks (pH 4.4 to 5.7). Somewhat higher pH values were obtained for the Fresh Water Marsh clays (pH 4.5 to 6.6) and Swamp clays and mucky clays (pH 5.2 to 6.1).

The organic matter content of the surface layers ranges from 33 to 78 per cent for the Swamp peats and mucks to 27 to 82 per cent for the Brackish peats and mucks and 30 to 50 per cent for the Fresh Water Marsh peats and mucks. Lower amounts of organic materials occur in the surface layers of Fresh Water Marsh clays (2.4 to 9.7 per cent) and Swamp clays and mucky clays (4.3 to 14.6 per cent).

The total nitrogen is highest in the organic soils, with 1.09 to 2.46 per cent for the Swamp peats and mucks, 0.93 to 2.25 per cent for the Brackish Marsh peats and mucks, and 1.05 to 1.66 per cent for the Fresh Water Marsh peats and mucks. The lowest values for total nitrogen are 0.12 to 0.45 per cent for Fresh Water Marsh clays and 0.19 to 0.59 per cent for the Swamp clays and mucky clays.

The values for water soluble cations, anions and salts were calculated on air-dry weight. Therefore, the recorded results for soils containing considerable amounts of organic materials are much higher than would be expected if the values were based on wet or moist field conditions. Calcium, potassium, sodium and chlorine are generally highest in the surface layers of the peats, mucks and clayey mucks of the marshes. Lowest values for these cations and anions are for samples of the Swamp clays, mucky clays, silty mucks and clayey mucks.

Total sodium chloride content of the surface layers ranges from 0.41 to 3.21 per cent for the Brackish peats, mucks, clayey mucks, mucky clays and clays to 0.03 to 0.72 per cent for the Swamp soils and the Fresh Water Marsh soils.

The highest values for total salts are 1.03 to 3.15 per cent for the Brackish Marsh peats and mucks and 0.59 to 2.06 per cent for the Brackish Marsh clayey mucks, mucky clays and clays. The Swamp silty mucks, clayey mucks, mucky clays and clays are the lowest in total salts, 0.06 to 0.71 per cent.

The values for sulfates (SO_4) range from a trace to very high for all of the samples. The higher contents of SO_4 were generally found in soils having the lowest pH values. Very high values for SO_4 were obtained from most of the surface samples of peats, mucks, silty mucks and clayey mucks of the marshes and swamps. The lowest amounts of SO_4 were found in the Swamp clays and mucky clays.

Engineering Properties of the Soils

The soil properties important in making interpretations for urban and recreational uses of the soils are explained in the following paragraphs. The values for these soil properties were obtained by laboratory analysis of some soil profiles and by estimations of the properties of other soils as a result of intensive field observations of their characteristics and their behavior. The engineering properties used are those described in the engineering handbook of the Soil Conservation Service (*15*).

Shrink-swell potential is an indicator of the change in volume that may be expected when a soil changes from a dry to a moist condition. This quality of a soil depends largely on the content of montmorillonitic clay, which cracks when dry and swells when wet. Movement of the clay due to shrinking and swelling under conditions of alternate wetness and dryness may result in damage to building foundations, highways and other structures on or in the soils. The classes of shrink-swell potential and the soils in each class are as follows:

Low to moderate—Jeanerette
Moderate—Patoutville, Cypremort
High—Alligator, Baldwin, Buxin, Iberia
Low to high—soils of the Coastal Marshlands and Swamps

Bearing capacity refers to the ability of a soil to support a static load. It is affected by texture, moisture content, density, consistence and gradation. Classes of bearing capacity for building of one or 2 stories built on conventional spread footings set at ordinary depth, and the soils in each class are as follows:

Moderate—Patoutville, Cypremort, Jeanerette
Moderately low—Baldwin
Low—Alligator, Buxin, Iberia
Very low—Organic soils and clays of the Coastal Marshlands and Swamps

Corrosion potential refers to the risk of damage to uncoated metal in contact with the soil through the action of the soil solution that forms an electrolytic cell. Some factors influencing corrosion are soil moisture content, conductivity of the soil solution, hydrogen ion concentration, oxygen concentration and organisms responsible for oxidation-reduction reactions. Classes of corrosion potential and the soils in each class are as follows:

Moderate corrosion potential—Cypremort
High corrosion potential—Patoutville, Jeanerette, Buxin, Baldwin, Alligator, Iberia, and soils of the Coastal Marshlands and Swamps

Wetness is classified according to the estimated time interval that free water stays in a soil after the saturation point has been reached. Soil wetness classes and the soils in each class are as follows:

Very wet—Coastal Marshlands and Swamps
Wet—Alligator, Iberia
Wet to moderately wet—Baldwin, Buxin
Moderately wet—Jeanerette, Patoutville
Slightly wet—Cypremort

Trafficability refers to the ease with which people can move about on foot, horseback or small vehicle (golf cart). It is influenced by the soil texture, height of the water table, rock or other coarse fragments and by flooding.

Subgrade or roadfill is material used for supporting the base layers in highway construction. Good subgrade material has a low shrink-swell potential and good traffic supporting capacity. A sandy material containing adequate binder rates high for subgrade use.

The engineering properties described above are the basis for the interpretations for urban and recreational uses of the soils given in Table 5. This information is intended for general, preliminary planning over large areas. It will not eliminate the need for detailed studies of areas that are selected for specific engineering uses.

Table 5.-Interpretations of engineering properties of the soils of St. Mary Parish, Louisiana.

	Degree of Limitation and Chief Limitations for Urban and Recreational Uses			
Soil Series and Type	Home sites (1 and 2 stories)	Building sites for light industries (3 stories or less)	Paved streets Parking areas Airport runways	Playgrounds Picnic areas Golf fairways Camp sites
Alligator clay Iberia silty clay loam	Severe wet high shrink-swell potential low bearing capacity over-flow hazard	Severe wet high shrink-swell potential low bearing capacity high corrosion potential for uncoated steel over-flow hazard	Severe wet poor (clay) subgrade material over-flow hazard	Severe wet poor trafficability over-flow hazard
Baldwin silt loam very fine sandy loam silty clay loam	Moderate to Severe wet to moderately wet high shrink-swell potential low bearing capacity	Moderate to Severe wet to moderately wet high shrink-swell potential low bearing capacity high corrosion potential for uncoated steel	Severe wet to moderately wet poor subgrade material high shrink-swell potential	Severe wet to moderately wet poor trafficability
Buxin silty clay loam silty clay	Severe wet to moderately wet high shrink-swell potential low bearing capacity	Severe wet to moderately wet high shrink-swell potential low bearing capacity high corrosion potential for uncoated steel	Severe wet to moderately wet poor subgrade material high shrink-swell potential low bearing strength	Severe wet to moderately wet poor trafficability
Cypremort very fine sandy loam silty clay loam	Slight slightly wet moderate shrink-swell potential moderate bearing capacity	Slight to Moderate slightly wet moderate shrink-swell potential moderate bearing capacity moderate corrosive potential for uncoated steel	Moderate slightly wet moderate shrink-swell potential moderate bearing capacity	Slight slightly wet
Jeanerette silt loam	Moderate severe if flooded moderately wet low to moderate shrink-swell potential moderate bearing capacity	Moderate to Severe severe if flooded moderately wet low to moderate shrink-swell potential moderate bearing capacity high corrosion potential for uncoated steel	Moderate to Severe severe if flooded moderately wet fair to poor subgrade material	Moderate severe if flooded moderately wet

(Continued)

Table 5.-(Continued) Interpretations of engineering properties of the soils of St. Mary Parish, Louisiana.

	Degree of Limitation and Chief Limitations for Urban and Recreational Uses			
Soil Series and Type	Home sites (1 and 2 stories)	Building sites for light industries (3 stories or less)	Paved streets Parking areas Airport runways	Playgrounds Picnic areas Golf fairways Camp sites
Patoutville silt loam very fine sandy loam	Moderate moderately wet moderate shrink-swell potential moderate bearing capacity	Moderate moderately wet moderate shrink-swell potential moderate bearing capacity high corrosion potential for uncoated steel	Moderate moderately wet poor to fair subgrade material	Moderate moderately wet
Soils of the Coastal Marshlands and Swamps clays overlain in many areas with organic materials 2 to more than 11 feet thick	Very Severe very wet low to high shrink-swell potential low to very low bearing capacity over-flow hazard	Very Severe very wet low to high shrink-swell potential low to very low bearing capacity high corrosion potential over-flow hazard	Very Severe organic materials not suited very wet many areas unstable	Very Severe very wet unstable layers of organic materials over-flow hazard

Methods of Analysis of the Soils Used for Farming

The following methods and procedures were used in the analyses of the 26 profiles of the soils that are used for farming:

Soil pH was measured on the moist soils in the field by using a Hellige-Truog test kit. Laboratory measurements of pH were made with the glass electrode pH meter.

Organic matter was calculated by a conversion factor (C x 1.72) from organic carbon determinations by the dry combustion method described by Piper (*12*).

Nitrogen was determined by the acid Kjeldahl digestion method described by Jackson (*3*).

Bases extractable by leaching the soil samples with ammonium acetate at pH 7.0, and by treatment with nitric, perchloric, and hydrochloric acids, were determined with the flame photometer.

Exchangeable hydrogen was determined by leaching the soil with 0.5*N* barium acetate at pH 7.0, and titrating to the phenopthalein end-point with standard sodium hydroxide.

The cation exchange capacity was calculated by summation of the extractable Ca, Mg, K, Na and H.

Phosphorus was extracted from the soil with 0.1*N* hydrochloric acid using a ratio of 1 part of soil to 25 parts of extracting solution. Values for phosphorus were determined by the chlorostannous-reduced molybdophosphoric blue color method in a sulfuric acid system as described by Jackson (*3*), and evaluated colorimetrically with the use of the flame photometer.

Selected soil samples were analyzed for total chemical composition of the soil and of the $<$ 2 microns clay, using the methods described by Hillebrand and Lundell (*2*). After sodium carbonate fusion, silica, iron, aluminum, titanium, manganese, calcium and magnesium were determined by the quantitative method described for silicate rocks. Following a hydrofluoric-nitric-perchloric acid digestion, the potassium and sodium were determined by the flame photometer; phosphorus was determined colorimetrically by the electrophotometer.

Soil samples of 12 profiles were prepared for X-ray diffraction analysis and analyzed by the North American Phyllips instrument having a copper target tube. Samples of profiles numbers 14, 15, 16, 20, 21, 26 and 27 were prepared by the methods described by Jefferies (*5*), and Jackson et al. (*4*), in which the organic matter and free iron oxides were removed and the clay fraction separated, dried and saturated with glycerol. These samples were analyzed by Dr. C. D. Jefferies, Agronomy Department, Pennsylvania State University. Samples of profiles 10, 11, 25, 30 and 33 were prepared by removing the organic matter, separating the clay fraction and saturating the clay with calcium and with ethylene glycol as described by Kunze and Templin (*7*). The samples were analyzed by Dr. G. W. Kunze, Department of Agronomy, Texas A and M University.

Methods of Analysis of Soils of the Coastal Marshlands and Swamps

The following methods and procedures were used in the analyses of 71 profiles of the coastal marshland and swamp soils which are not used for farming:

Soil pH was measured by the method described by Peech et al. (*10*), using a glass electrode pH meter.

Organic matter was calculated by a conversion factor (C x 1.72) from the organic carbon determinations by the dry combustion method described by Kolhoff and Sandell (*6*).

Nitrogen was determined by the procedure described by Piper (*12*).

Methods used for the determinations of water soluble cations, anions and salts were essentially the A.O.A.C. methods for alkali salts (*1*). A portion of the filtrate was used to determine the calcium, potassium and sodium with the flame photometer. Sulfates were determined qualitatively as described by Lunt et al. (*8*). Chlorine was determined by titration with standard silver nitrate solution, using potassium chromate as an indicator. Total sodium chloride was calculated from the values for chlorine. Total salt content was determined by evaporation of a 50-ml aliquot of the filtrate and fusion of the residue to remove the organic matter.

Samples from all horizons of 10 soil profiles were analyzed for total chemical composition, following procedures similar to those described by Hillebrand and Lundell (*2*) for the oxides of silica, iron, aluminum, titanium, calcium, magnesium and manganese, with the following exceptions: Iron was reduced with a G. Frederich Smith zinc spiral instead of hydrogen sulfide. Sulfur and chlorine were determined by the Parr Bomb method (*9*). Methods for sodium, potassium and phosphorus determinations were similar to those described by Shapiro and Brannock (*14*), and the values were determined with the flame photometer. Methods for determinations of moisture and loss on ignition were similar to those described by Robinson (*13*). All calculations listed in these investigations were made on a moisture-free basis except those for the water soluble salts, which were calculated on air-dry weight.

Definitions of Soil Horizon Symbols

In general descriptions of soils, the terms commonly used are surface soil (A horizon), subsoil (B horizon) and substratum (C horizon). Symbols used in detailed descriptions of soils are A, B and C for the different soil horizons and arabic numbers and lower case letters for subdivisions of the soil horizons, as listed below.

Ap —	a surface mineral soil layer which has been disturbed or mixed as by plowing.
Ap_1, Ap_2, Ap_3—	subdivisions of the Ap horizon due to differences in one or more of the following characteristics: color, texture, structure, consistence.
A-C —	a horizon transitional between the A and C, and having properties of both.
B_{2t} —	the layer of maximum accumulation of silicate clay that has concentrated by leaching from soil horizons above.
B_{21t}, B_{22t} —	subdivisions of the B_2t due to differences in one or more of the following characteristics: color, texture, structure, consistence.
B_3 —	a transition horizon between B and C, but dominated by characteristics of the B.
C —	a mineral soil horizon that lies outside the zone of major biological activity; relatively little affected by soil forming processes; either like or unlike the material from which the solum is formed.
C_1, C_2, C_3—	subdivisions of the C horizon, each requiring a separate description because of differences in color, texture, structure or consistence.
Cg —	dominantly gray, strongly gleyed C horizon.
Cg_1, Cg_2 —	subdivisions of Cg due to differences in one or more of the following characteristics: color, texture, structure, consistence.
IIC —	a C horizon having materials strongly contrasting in texture, color, or consistence to those of an overlying horizon; e.g., sandy loam C underlying a clay B horizon.
IIC, IIC_2, IIC_3—	subdivisions of IIC due to differences in one or more of the following characteristics: color, texture, structure, consistence.

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Social Factors Related to The Rapid Adoption Of Soybeans By Louisiana Farmers

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Social Factors Related to the Rapid Adoption of Soybeans by Louisiana Farmers

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Part I. Introduction

The soybean is one of the oldest crops in the United States. It was "adopted to Pennsylvania" in the 1800's.[1] The soybean was actually cultivated in China long before written records were kept. However, the modern era of soybean production did not occur in the United States until the late 1930's and early 1940's. The demand for soybeans during and following World War II stimulated their production in this country. From 1950 to 1966, soybean acreage in the United States advanced nearly 150 percent; however, in Louisiana, Alabama, Florida, Georgia, Mississippi, and Tennessee total acreage approached a 220 percent gain. By 1967, Louisiana farmers were planting to soybeans approximately three times the acreage seeded in 1962.[2]

Newly cleared lands, pasture, and other croplands are being planted to soybeans throughout Louisiana. Farmers have adopted relatively simple practices such as new varieties of an existing crop or small variations on a presently used item of machinery. They have also adopted more complex new practices involving what in reality is a series of changes in their existing farming practices. A more complex innovation or change might involve changes in machinery, changes in weed control practices, changes in water utilization, and changes in marketing facilities, that is, a complex of changes. A good example of a relatively simple practice adoption with farmers using existing production equipment and marketing facilities is illustrated in the rice producing areas of the state. A three-year rotation of crops is usually followed by the farmers, that is, leaving the land idle for two years after one crop of rice. Large acreages of land are thus available for soybeans since this crop can be grown on the fallow acreage. The farmers use their rice combines to harvest the crop, and the beans are sold at the rice marketing facilities.[3] In other specialty areas such as sugar cane and cotton areas, however, the adoption of commercial soybean production represents a complex of changes since many different techniques, types of equipment, and marketing facilities are required.

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[1] Robert E. Sweeney, "Soybeans: America's Cinderella Crop," *Monthly Review, Federal Reserve Bank of Atlanta,* LII (June, 1967), p. 74.

[2] *Ibid.,* pp. 74-78. Soybean production in Louisiana has actually increased from 4,500 acres in 1929 to over a million acres today according to "The Investment Impact," *The LSU Outlook,* XVI (May, 1969), p. 2.

Historically speaking, radical innovative changes often are the result of a crisis situation.[4] Many Louisiana farmers have been placed in a crisis situation by the reduction of the government acreage allotment for their primary crop. Farmers were in real need of an alternate crop. The planting of soybeans has in some degree been a response to this situation.

Objectives

The general purpose of this study was to explore the sociological context of the recent rapid increase in the production of soybeans in the state of Louisiana. This is a most interesting example of the rapid diffusion of a crop which represents a relatively new major enterprise to the state. Detailed objectives were as follows:

1. To determine the relationship of selected socio-economic characteristics of farmers to the adoption of soybeans as a farm enterprise.
2. To determine what sources of information were relied upon by farmers in the adoption (or rejection) of this crop.
3. To determine what factors account for the unusually rapid spread of soybean farming in the state.
4. To trace the patterns of diffusion of soybean production within the state.

Need for the Study

One of the major concerns of educators, agricultural extension personnel, businessmen, and government agencies interested in rural development has been getting farmers to utilize on crops and other enterprises the information obtained from agricultural research stations. This problem is unique to production agriculture in comparison with other production systems because management decisions are made by a large number of individual operators and not by a select number of management and administrative personnel who occupy authority positions in large bureaucracies. The technological and other changes which are characteristic of modern agriculture must be transmitted to and accepted by large numbers of individual operators. Extension agents and rural sociologists have learned a lot about the process of diffusion of ideas to farmers in the past 40 years. Yet, much is still to be learned. For example, why should a crop like soybeans sweep the state in a few short years while another crop takes years to be accepted on a limited scale?

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[3] Sweeney, *Ibid.*, p. 78.

[4] Allan R. Holmberg, "The Changing Values and Institutions of Vicos in the Context of National Development," *The American Behavioral Scientist*, Vol. 8, No. 7 (March, 1965), p. 5.

An analysis of the diffusion of soybeans among farmers in Louisiana should provide insights to educators and extension workers and aid in the attempt to diffuse research information throughout the nation.

There have been no studies of the rate and/or pattern of the diffusion of soybeans in Louisiana or the nation so far as the authors know. However, many studies of the acceptance of innovations have been made in other states which could be used to give background material for this research. James Copp emphasizes the need for diffusion studies which can contribute to our understanding of how people are influenced to acquire new knowledge of techniques.[5]

Part II. Conceptual Framework

In symbolic interaction theory, man is perceived as acting according to his interpretation of a stimulus rather than acting directly toward the stimulus. Thus, the response of an individual is largely due to the manner in which he interprets the situation. Since man is a "calculating creature" and interprets a given stimulus prior to responding, it is rather difficult to predict man's behavior. However, if the various factors which tend to influence an individual in his interpretation of a given situation can be determined, human behavior would become more predictable.

Farm management decisions are made in an uncertain environment in which many important factors are beyond the control of the individual. Also, no matter how much information the decision-maker has at his disposal, short-run fluctuations in such variables as price and weather add to the uncertainty of decision-making. The role of information and knowledge in the decision-making process is to reduce uncertainty. The more knowledge the individual has concerning the consequences of a given action, the more accurate will be his prediction of the outcome.

With reference to the decision-making process of determining whether or not to adopt a particular innovation, various alternatives are available to the individual. Social scientists should be in a better position to predict which of the alternatives an individual will choose if knowledge concerning significant influential factors (credit, etc.) is available.

Part III. Sampling Procedure and the Research Population

Sampling Procedure

The three parishes from which data for this study were obtained are Pointe Coupee, Richland, and Jefferson Davis, which are located, respectively, on the side of the Mississippi River across from Baton Rouge,

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[5] James Copp, *Our Changing Rural Society* (Ames: Iowa State University Press, 1964), p. 267.

Louisiana, in northeastern Louisiana, and in southwestern Louisiana. These parishes were selected because they represent divergent farm regions of the state, with sugar cane being the major crop in Pointe Coupee, cotton the main crop in Richland, and rice the principal crop in Jefferson Davis Parish. Since soybean production has become a major cash crop in these three parishes, this study attempted to determine if the factors related to the acceptance of this new farm practice would vary in these divergent farming regions.

A random selection of commercial soybean growers was made from lists of soybean producers in Pointe Coupee, Jefferson Davis, and Richland Parishes. These lists of growers, which were obtained from the county extension agents, were the most recent and reliable source of this information available to the researchers. Through the use of a table of random numbers a sample of 35 soybean producers was selected from each of the three parishes, although all were not interviewed.

An additional sample of all rural dwellers in Pointe Coupee Parish was drawn in a random manner. Then only those rural dwellers who met the United States Census Bureau's definition of a farmer were interviewed. In order to qualify as a farmer under this definition, one must have farmed 10 or more acres and have sold at least $50 worth of produce in the preceding year, or if he farmed less than 10 acres of land he must have sold more than $250 worth of produce in the preceding year. Of the original 250 dwellings selected, only 48 qualified to be interviewed when the preceding definition of "farmer" was applied. This sample is referred to as the "non-adopter" sample. Due to a shortage of time and funds, non-adopter samples were not obtained in Jefferson Davis and Richland Parishes. The actual number of "adopter"* questionnaires completed was 35 from Richland Parish, 31 from Jefferson Davis Parish, and 30 from Pointe Coupee Parish.[6] Two persons were actually in both of the Pointe Coupee samples, but were counted only once—in the soybean adopter sample.

Research Instrument

The research instrument used in this investigation was the interview schedule. The schedule developed for this study included questions which would provide data to achieve the objectives set forth earlier in this report.

In June 1966, interviews were completed with a total of 144 farmers in the three above-named parishes. A pre-test was conducted prior to the interviews to eliminate non-pertinent questions and clarify ambiguous ones.

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*An "adopter" is defined as anyone who is growing soybeans for commercial purposes.

[6] The total number of persons interviewed in the three soybean adopter samples was 96, with the distribution being fairly equal in each of the three parishes. The sample of non-adopters totaled 48 persons.

Part IV. Characteristics of the Population

This aspect of the report focuses on the relationship of selected socio-economic characteristics to the adoption of soybeans as a farm enterprise.

Age

The average age for the respondents in each of the samples ranged from a low of 41 years in Jefferson Davis Parish to a high of 60 years for the soybean adopters in Richland Parish. In Pointe Coupee Parish the average age of adopters was 42 years and for non-adopters, 47 years. The age gap between these adopters and non-adopters is not great enough to permit any firm conclusions in regard to the importance of age as a factor related to the adoption or rejection of soybeans.

Educational Achievement

One might assume that with an increased amount of formal education, a farmer is more adequately informed and therefore should be in a better position to make rational decisions regarding the adoption alternative (to adopt or not to adopt soybeans). However, having a greater amount of formal education does not necessarily mean the farmer is better informed about specific farm practices. From the data analyzed in these four samples, it was found that the Pointe Coupee non-adopter sample had the lowest level of education (arithmetic mean = 8.4 years of schooling). The Pointe Coupee adopter sample had the highest level of education (arithmetic mean = 11.5 years of schooling), followed by the Jefferson Davis (10.6) and Richland (8.9) samples. The contrasting averages in the Pointe Coupee samples are quite revealing, with a difference of over three years of formal education. Perhaps an increase in formal education is conducive to adoption of innovative farm practices. However, it must be made clear that adoption of soybeans is not assumed to be more "rational" than non-adoption. Particularly for small farmers, it may be non-rational in economic terms to become a soybean farmer. It may be that these farmers had fewer years of formal education and were less likely to adopt soybeans, but their choice not to adopt soybeans was a rational one.

Gross Family Income

Each respondent was asked to state his average gross family income for the three-year period from 1964 through 1966. The soybean adopters had a much higher average gross family income than did the non-adopters. The non-adopters reported an average income of $8,620 for the three-year period while the adopters' average ranged from a high of $17,300 in Jefferson Davis Parish to a low of $12,630 in Pointe Coupee Parish. Gross family income for the Richland Parish group averaged $14,140. Perhaps with a higher income one is in a better position to risk adopting a new farm practice. Also, a farmer with a higher income probably is better able to obtain investment credit for a new farm practice than is one with a much lower income.

Farm Size

The Pointe Coupee non-adopters had a median farm size of 100 acres per farm, which corresponded to its low income. The median size of farms for the Pointe Coupee adopter sample was 1,150 acres, which is over eleven times the farm size of the non-adopters in the same parish. The median size farm for the Richland and Jefferson Davis samples was 450 acres. On the basis of the Pointe Coupee samples, the farmer with limited acreage seems less likely to adopt a new farm practice than is one who has a much larger farm operation. A farmer is just not equipped to risk adopting a capital-consuming farm practice such as soybean production when he operates on such a small scale.

Participation in Community Organizations

The non-adopters of soybeans participated less frequently in community organizations than did adopters. The average number of organizations participated in by non-adopters was 1.8, while participation of adopters ranged from a high of 2.6 in Jefferson Davis Parish to a low of 2.2 in Richland Parish, with Pointe Coupee falling in between with an average of 2.5. Information concerning farm practices may be acquired at these various community meetings; thus, it would follow that adopters of a specific farm practice are more likely to be active in community organizations.

Discussion

From the foregoing discussion, we conclude that education, income, farm size, and participation in voluntary organizations are related to the adoption of soybeans in Louisiana. Since other studies have shown these four characteristics to be interrelated, we are not surprised that all four are related to adoption.*

One must also be aware that all changes in management practices are not of the same level of importance. The adoption of soybeans differs greatly from the adoption of some changes in the farm operation which are far less complex (for example, planting a new variety of seed). The adoption of soybeans not only requires a different seed, but for most new producers it involves new tillage practices, different fertilizer programs, new and different machinery, and different marketing facilities. Thus, we are examining not merely one change but a complex of changes.

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*It is possible that one of the factors such as farm size is more highly related than the other three factors. While this remains an academic and methodological question, it is not of great concern to the change agent since the four characteristics usually appear together.

Since for some farmers new equipment and new marketing outlets are required, it may be economically rational for farmers with large acreage to adopt soybeans. On the other hand, the adoption of soybeans by a farmer with small acreage might be economically non-rational since he simply would not have enough acres over which to spread the new costs. Often the innovative small farmer does not have the alternative of hiring custom work or cooperating with other small farmers since by definition he is of a minority of early adopters. Thus, no effort is being made here to suggest that all farmers should adopt soybean production, but rather we are interested in the characteristics of those who have adopted soybean production. These findings should not be generalized to all types of adoption, since differences might be observed of a simple change such as changing variety of seed or changing the fertilizer program.

Part V. Information Sources Utilized in Farm Practices

As previously stated, a second objective of this study was to investigate the information sources useful to the farmer in making decisions concerning farm practices. Each respondent was asked to state the various sources which were influential to him concerning farm practices.

Mass Media

Table 1 shows the distribution of mass media as information sources for farm practices. It is of significance to note that the average number of mass media sources used by the non-adopters of soybeans was less (3.3) than for the soybean adopters (4.0 in Pointe Coupee, 4.6 in Richland, and 4.5 in Jefferson Davis). The adopters tended to make better use of mass media sources than did the non-adopters. The most frequently used mass media source was *The Progressive Farmer,* according to Table 1. *Farm Journal* was also a source which was relied upon frequently by the farmers in this study. Radio and television were sources of farm information to approximately half of the farmers interviewed. A daily newspaper was read by over half of the adopters of soybeans for farm practice information, but it was read less frequently (42 percent) by the non-adopters.

Agencies

Each respondent was asked which agencies he used as information sources regarding farm practices. From Table 2 the average number of agencies used by each respondent is revealed to be less for the non-adopters than for the adopters of soybeans (3.6 for non-adopters, 3.9 for adopters in Pointe Coupee and Jefferson Davis, and 4.1 for the adopters of Richland Parish). The county agent was the most frequently cited source of information by both adopters and non-adopters of soybeans. Over 85 percent of all adopters stated that the county agent was utilized

TABLE 1.—Percentage Distribution of Mass Media Used as Information Sources on Farm Practices by Adopters and Non-Adopters

MEDIA Use or Non-Use	NON-ADOPTERS Pointe Coupee (N=48)	ADOPTERS Pointe Coupee (N=30)	Richland (N=35)	Jefferson Davis (N=31)
	— — — — — — — —	Percent	— — — — — — — —	
The Progressive Farmer				
Yes	56.3	70.0	80.0	74.2
No	43.7	30.0	20.0	25.8
Successful Farming				
Yes	10.4	20.0	5.7	12.9
No	89.6	80.0	94.3	87.1
Farm Journal				
Yes	56.2	63.3	60.0	71.0
No	43.8	36.7	40.0	29.0
The Farm				
Yes	12.5	10.0	20.0	19.4
No	87.5	90.0	80.0	80.6
Daily Newspaper				
Yes	41.7	56.7	65.7	51.6
No	58.3	43.3	34.3	48.4
Weekly Newspaper				
Yes	20.8	16.7	22.9	35.5
No	79.2	83.3	77.1	64.5
Radio				
Yes	62.5	43.3	57.1	29.0
No	37.5	56.7	42.9	71.0
Television				
Yes	62.5	46.7	57.1	38.7
No	37.5	53.3	42.9	61.3
Other*				
Yes	31.2	43.3	28.6	35.5
No	68.8	56.7	71.4	64.5
Other*				
Yes	6.2	16.7	8.6	19.4
No	93.8	83.3	91.4	80.6

*Two other spaces were provided in case the respondent named more than one additional source.

by them as a source of farm practice information, while over 79 percent of the non-adopters of soybeans listed the county agent as an information source. One concludes from the evidence in this study that the county agent is used by the farmers in his parish for farm practice information.

Other agencies frequently used for farm practice information by the farmers in this study were the Soil Conservation Service (over 40 percent of all respondents), LSU specialists (over one-third of adopters), LSU bulletins (over one-third of all adopters), local dealers (ranged from 20 to 40 percent of all respondents), seed companies (over 50 percent of adopters and 42 percent of non-adopters), and commercial companies

TABLE 2.—Percentage Distribution of Agencies Used as Information Sources on Farm Practices by Adopters and Non-Adopters

AGENCIES Use or Non-Use	NON-ADOPTERS Pointe Coupee (N=48)	ADOPTERS Pointe Coupee (N=30)	 Richland (N=35)	 Jefferson Davis (N=31)
	– – – – – – – –	Percent	– – – – – – – –	
County Agent				
Yes	79.2	86.7	85.7	96.8
No	20.8	13.3	14.3	3.2
County Youth Assistant				
Yes	0.0	6.7	5.7	0.0
No	100.0	93.3	94.3	100.0
Soil Conservation Service				
Yes	47.9	43.3	40.0	41.9
No	52.1	56.1	60.0	58.1
LSU Specialists				
Yes	27.1	43.3	34.3	38.7
No	72.9	56.7	65.7	61.3
LSU Bulletins				
Yes	31.2	43.3	42.9	35.5
No	68.8	56.7	57.1	64.5
LSU Short Courses				
Yes	0.0	10.0	5.7	3.2
No	100.0	90.0	94.3	96.8
Voc. Ag. Instr.				
Yes	12.5	3.3	20.0	25.8
No	87.5	96.7	80.0	74.2
Local Dealer (Farm Supplies)				
Yes	31.2	20.0	40.0	35.5
No	68.8	80.0	60.0	64.5
Seed Companies				
Yes	41.7	63.3	71.4	54.8
No	58.3	36.7	28.6	45.2
Salesmen (Farm Supplies)				
Yes	12.5	23.3	25.7	12.9
No	87.5	76.7	74.3	87.1
Commercial Companies				
Yes	20.8	30.0	42.9	48.4
No	79.2	70.0	57.1	51.6
Average Number of Agencies Used by Each Respondent	3.6	3.9	4.1	3.9

(ranged from 30 to 48 percent of soybean adopters). Thus, numerous agencies are used by the farmers in these three Louisiana parishes as information sources for farm practices.

Neighbors and Friends

Each respondent was asked to list the neighbors and friends who were used as information sources for farm practices. The average number of persons relied upon ranged from 2.1 for the Richland adopters to

2.6 for the Pointe Coupee adopters. The Jefferson Davis adopters used an average of 2.6 friends and neighbors as information sources, while the Pointe Coupee non-adopters used an average of 2.1 friends and neighbors for advice on farm practices.

Ranking of Information Sources

After each respondent had stated the sources of information he used for farm practices, he was asked to rank the three sources which were most valuable to him. The county agent was most often listed as the top-ranking source of information for farm practices. The reason most often cited for naming the county agent as the most significant source was because he is "up-to-date with research" and is an "intelligent, able-minded individual." Most of the respondents seemed to hold the county agent in high esteem and were most appreciative of his aid to them.

Of the three most valuable sources listed, government agencies were listed most frequently. The mass media was seldom listed as one of the three major sources from which information on farm practices was obtained. The general consensus regarding friends and neighbors as major sources of information was that these persons had learned from experience and were, therefore, a reliable source to which one could turn.

Information Sources Regarding Soybeans

To determine the sources of information used by farmers to learn about soybeans, each of the respondents was asked to state where he first heard about the favorable aspects of raising commercial soybeans in Louisiana. Table 3 shows the results of this question. The respondents (50.8 percent) gave the personal source, neighbor and/or friend, as the most significant means of first informing them about the importance (profit potential) of soybean production in Louisiana.

The respondent was then asked with whom he had discussed or from

TABLE 3.—The Initial Source of Information About the Importance (Profit Potential) of Raising Soybeans Commercially in Louisiana

SOURCE OF INFORMATION	NON-ADOPTERS	ADOPTERS		
	Pointe Coupee (N=48)	Pointe Coupee (N=30)	Richland (N=35)	Jefferson Davis (N=31)
	Percent			
Neighbor or Friend	45.8	50.0	42.9	64.5
County Agent	12.5	3.3	22.9	12.9
Relative (not member of immediate family)	4.2	20.0	8.6	12.9
Impersonal Sources	12.5	6.7	5.7	0.0
Other	4.2	20.0	11.3	9.7
No Response	20.8	0.0	8.6	0.0
TOTAL	100.0	100.0	100.0	100.0

TABLE 4.—Source With Whom Farmer Discussed the Technical Farming Aspects of Growing Soybeans

SOURCE	NON-ADOPTERS	ADOPTERS		
	Pointe Coupee (N=48)	Pointe Coupee (N=30)	Richland (N=35)	Jefferson Davis (N=31)
	———	——— Percent	———	———
Neighbor or Friend	14.6	20.0	17.1	16.1
County Agent	8.3	43.3	48.6	41.9
Relative (not member of immediate family)	0.0	10.0	0.0	12.9
Impersonal Sources	2.1	3.3	8.6	0.0
Soil Conservation Service	0.0	6.7	2.9	16.1
Other	4.2	13.4	14.2	9.8
No Response	70.8	3.3	8.6	3.2
TOTAL	100.0	100.0	100.0	100.0

whom he had heard about the technical aspects of soybean production. The results of this question are shown in Table 4. The county agent was relied upon rather heavily by the adopters of soybeans for technical advice (over 40 percent in each adopter sample listed the county agent as the main source). Thus, the initial source of information concerning soybean production came from neighbors and friends, but the farmer turned to his county agent when technical advice concerning soybean production was needed.

The respondent was next asked with whom he had discussed or from whom he had heard about the financial advisability of growing soybeans. The results of this question are shown in Table 5. No one source

TABLE 5.—Source With Whom Farmers Discussed the Financial Aspects of Growing Soybeans

SOURCE OF INFORMATION	NON-ADOPTERS	ADOPTERS		
	Pointe Coupee (N=48)	Pointe Coupee (N=30)	Richland (N=35)	Jefferson Davis (N=31)
	———	——— Percent	———	———
Neighbor or Friend	20.8	13.3	14.3	22.6
County Agent	2.1	10.0	20.0	12.9
Relative (not member of immediate family)	2.1	10.0	2.9	19.4
Impersonal Sources	2.1	6.7	2.9	3.2
Soil Conservation Service	0.0	6.7	17.1	19.4
Seed and Feed Dealer	2.1	3.3	5.7	3.2
Banker	0.0	13.3	5.7	9.7
Other Businessmen	2.1	10.0	5.7	0.0
Other	0.0	13.4	0.0	3.2
No Response	68.7	13.3	25.7	6.4
TOTAL	100.0	100.0	100.0	100.0

tended to be predominant. The answers to this question revealed that numerous sources were relied upon by the farmers, with no specific pattern evolving.

The opinion of the farmer's banker and friends concerning soybean adoption was ascertained by asking the respondent to state how his banker or financier and friends felt about raising soybeans. Table 6 shows the results of this questioning. The attitude of both their bankers and friends toward soybean production was favorable for the majority of respondents.

Since his friends and his banker were in agreement with his growing soybeans, this support might have served as a strong influence to the farmer in his decision concerning soybean adoption. If he needed production operating capital in order to grow soybeans, a favorable attitude on behalf of his banker or financier was of special significance to him.

TABLE 6.—Attitude of Banker and Friends Concerning Soybean Production

ATTITUDE OF	NON-ADOPTERS	ADOPTERS		
BANKER	Pointe Coupee (N=48)	Pointe Coupee (N=30)	Richland (N=35)	Jefferson Davis (N=31)
	— — — — — — — — Percent — — — — — — — —			
Opposed	4.2	0.0	0.0	0.0
Neutral	6.3	6.7	8.6	0.0
Favorable	37.4	90.0	71.4	90.3
No Response*	52.1	3.3	20.0	9.7
TOTAL	100.0	100.0	100.0	100.0
ATTITUDE OF FRIENDS				
Opposed	4.2	6.7	0.0	0.0
Neutral	12.5	10.0	5.7	6.5
Favorable	56.3	80.0	82.9	93.5
No Response*	27.0	3.3	11.4	0.0
TOTAL	100.0	100.0	100.0	100.0

*The no-response category includes the variety of reasons why the farmers did not know their bankers' or friends' attitudes about soybean production.

Part VI. Soybean Adoption

Reasons for Growing Soybeans

In an effort to determine some additional factors related to the rapid adoption of soybeans, each adopter was asked to name the major reasons why he began growing commercial soybeans. The various responses to this open-ended question were categorized and are listed below:

Times Mentioned	Reasons
55	Good cash crop
4	Reduced acreage allotment in major crop
8	Use of idle land, diversification
5	Other crops unsatisfactory
8	Best second crop
47	Soybeans are inexpensive and easy to grow; soil improvement
2	Good rotation crop
2	Everybody else is growing them

Although it was mentioned relatively few times, reduced acreage allotments in major crops was a basic given in most of the farmers' situations.

From the reasons cited above, it appears that many of the farmers turned to soybean production because they were seeking a cash crop which had no acreage allotment restrictions. Due to the acreage allotments on their primary crops, farmers had land which was not in production. Since soybeans are a good cash crop, with the advantages of requiring less attention than many crops and improving the soil, many farmers viewed this new crop as presenting an attractive alternative to their current problem of having idle cropland. The reduction of acreage allotments established by the government essentially presented a crisis situation for the farmer. His potentially productive cropland could no longer be utilized for the production of his primary crop. He needed another crop which was free of acreage control and which would provide him a profitable return.

When relating the reasons for adopting soybeans to the socio-economic characteristics of the adopters—especially the size of the farm—one might conclude that acreage allotments in a primarily one-crop farming region are economically more detrimental to the small farmer than to the larger farmer. While the large farmer has the resources for producing a new crop which economically is a good alternative, it may not be economically rational for the small farmer to adopt soybean production when his initial cost would be quite large relative to his total production.

The farmers in this study who were not adopters of soybean production on a commercial basis were asked if they had ever grown soybeans, and if so, for what reason. The non-adopters' most frequent answers to this question were: for weed control, soil conservation, feed for cattle. Some of these farmers had been planting soybeans with their other crops for many years as a means of improving the soil.

Migration Patterns of Soybean Adopters

The final objective of this report was to ascertain the pattern of the diffusion of soybeans in Louisiana. Table 7 presents evidence that a high proportion of the adopters of soybean production had immigrated to the observed parish. A much higher percentage of adopters had moved into the observed parish from outside than was true of non-adopters. Only 14 percent of the non-adopters had moved into Pointe Coupee from another parish, whereas between one-third and one-half of the farmers in the adopter samples had moved into the observed parish from outside. In the Pointe Coupee adopter sample, over one-fourth of the farmers had moved into the parish from outside the state of Louisiana.[7]

TABLE 7.—Percentage of Soybean Adopters and Non-Adopters Who Had Previously Farmed Outside the Observed Parish

LOCATION OF	NON-ADOPTERS	ADOPTERS		
PREVIOUS FARM EXPERIENCE	Pointe Coupee (N=48)	Pointe Coupee (N=30)	Richland (N=35)	Jefferson Davis (N=31)
		Percent		
North Louisiana	0	3	30	16
South Louisiana	14	20	0	19
Southern U.S. Outside Louisiana	0	23	6	0
Other Sections Outside Louisiana	0	3	3	0
TOTAL	14	49	39	35

Year of Adoption of Soybeans

The farmers were asked when they first adopted soybeans for commercial purposes. Table 8 shows that soybean adoption occurred earlier in Pointe Coupee and Richland Parishes (1945) than in Jefferson Davis Parish (1954). Although the first farmer to produce soybeans in the

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[7] The pattern of diffusion of soybeans within the state tends to be southward, with no adopters in this investigation going from south Louisiana to the northern parish of Richland.

TABLE 8.—Year of Adoption of Soybeans

Item	Richland	Pointe Coupee	Jefferson Davis
Earliest Adopter*	1945	1945	1954
Average Year of Adoption	1959	1961	1964

*The earliest adopter in the respective sample.

Pointe Coupee sample started producing commercial soybeans in the same year as the first farmer in the Richland sample, in general soybean production in Richland preceded the production in Pointe Coupee to the south by a couple of years. It is of interest to note that soybean production on a commercial basis did not actually boom until the late 1950's and early 1960's.

The Future of Soybeans in Louisiana

In order to ascertain the future prospects of soybean production in Louisiana, each respondent was asked if he presently intended to grow soybeans in the future. The results of this questioning appear in Table 9. The overwhelming majority of farmers who were currently growing soybeans for commercial purposes planned to continue growing them. In addition, over 20 percent of the non-adopters of soybeans in 1966 intended to grow soybeans in the future. Thus, it appears that one can look forward to an increase in the production of soybeans in Louisiana. One of the concerns voiced by some farmers about the future of soybean production in Louisiana was the fear that the government would place acreage allotments on soybeans if increased acreage was planted.

TABLE 9.—Percentage Distribution of Farmers According to Intentions Concerning Soybean Production in the Future

DO YOU PRESENTLY INTEND TO GROW SOYBEANS IN THE FUTURE?	NON-ADOPTERS	ADOPTERS		
	Pointe Coupee (N=48)	Pointe Coupee (N=30)	Richland (N=35)	Jefferson Davis (N=31)
	— — — — — — — — Percent	— — — — — — — —		
Yes	20.8	86.7	74.3	61.3
No	50.0	6.7	0.0	3.2
Do Not Know	12.5	3.3	0.0	6.5
No Response	16.7	3.3	25.7	29.0
TOTAL	100.0	100.0	100.0	100.0

When the farmers were asked why they intended to start or continue producing soybeans, the following responses, which were similar to the reasons listed by the adopters for producing soybeans, were given:

Times Mentioned	Reasons
51	Good cash crop
16	Good use for idle land
2	Good market
12	Good yield per acre and a good return for investment made
21	Allotments on other major crops make this a good crop to plant
9	Good second crop
2	Good rotation crop

VII. Summary

The rapid spread of soybean production in three Louisiana parishes was investigated in this study. A total of 144 farmers were interviewed in order to obtain data concerning the diffusion of soybean production. Age did not differ significantly between adopters and non-adopters. However, other socio-economic characteristics such as educational achievement, gross family income, family size, and participation in community organizations did show some rather striking differences between the adopters of soybean production and the non-adopters. The following shows the differences which were found between the adopters and the non-adopters:*

1. The educational achievement for adopters was higher than for the non-adopters.
2. The gross family income of the adopters was higher than for the non-adopters.
3. The average farm size was greater for the adopters than for the non-adopters.
4. Participation in community organizations was higher for the adopters than for the non-adopters.

The county agent (the Extension Service) was most often listed as the top ranking source of information about farm practices. *The Progressive Farmer* was the most frequently listed mass media source used by the farmers to obtain information regarding farm practices.

With regard to the specific practice of soybean production, the farmers' neighbors and friends were the most influential source in originally informing the adopters of the potential of soybean production. Once the farmers were aware of the possibility of producing soybeans on their farms, however, the farmers most often consulted the county agent for technical and financial advice concerning soybean production.

The adopters indicated that their friends and bankers were very favorable toward the production of soybeans. The support of friends is perhaps important to some farmers when they are undergoing the uncertainty accompanying the use of a new farm practice. The banker, however, is in a more powerful position. While the banker's verbal support of a new farm practice might be desired, his financial support (or lack of support) may in fact be a crucial variable in determining whether or not a farmer will adopt a new practice. We should not, therefore, be surprised to find a favorable attitude toward soybean production on behalf of the bankers who handled the financial matters of the adopters. Those farmers whose bankers were not favorably disposed to soybean production are very likely still among the non-adopters if they needed additional financial backing before they could adopt the soybeans. This suggests that a "change agent" interested in introducing a new practice which requires rather substantial capital should not overlook the importance of persons in positions to provide financial assistance. The fact that a high percentage of the sample farmers who first produced soybeans in the parish came from outside the area may be because they received financial support from outside the local parish, and capital for investment in soybeans was not as readily available locally.* In addition, bankers within the parish may have been more eager to support farmers who had previous experience producing soybeans than farmers who had not had such experience.

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*These differences, of course, are most valid for Pointe Coupee Parish adopter versus non-adopter samples, but also hold when the non-adopters of Pointe Coupee are compared with the adopters of all three parishes.

Over one-third of adopters of soybeans had moved into the observed parishes. Perhaps the early adopter of a new complex farm practice is one who comes into a new area bringing the idea with him. He is probably watched very closely by his new neighbors and perhaps sets an example which his observers follow if he is successful. It was interesting to note that over one-fourth of the soybean adopters in Pointe Coupee Parish had moved into the parish from outside the state of Louisiana. Within the state, the idea of soybean production appeared to have diffused from north to south.

History has shown that a crisis situation often leads to change. This was apparently an important reason for the rapid expansion of soybean production in Louisiana. The increase in soybean production in the late 1950's and the early 1960's came at a time when the acreage allotment for the major crop in the area was being reduced. Many of the farmers indicated that they had grown soybeans in the past on a non-commercial basis to enrich their soil and feed livestock. However, the need for a good cash crop with no acreage allotment appears to be the major impetus behind the sudden increase in soybean production in the state.

From the responses of the farmers interviewed, it appears that soybeans will continue to be produced in Louisiana. The large majority of current soybean adopters plan to continue growing soybeans in the future, while over 20 percent of the non-adopters plan to begin growing soybeans for commercial purposes in the near future. We will probably continue to see an expansion of soybean production in Louisiana if the government does not set acreage allotments for soybeans, as some producers fear, and the market demand remains strong.

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*Unfortunately, we did not ask the farmers the location of their bank.

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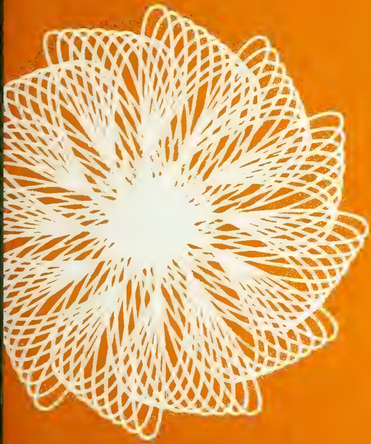
Predicting Technological Change On Farms:

A Study of Louisiana Farmers



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Predicting Technological Change on Farms: A Study of Louisiana Farmers

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Pedro F. Hernandez and Pedro R. Acierto*

Introduction

There have been a number of studies devoted to the social implications of increasing farm technology. These studies, including two done in Louisiana,[1] have provided important information on the nature of changes on farms. Their authors have not only identified the specific trends that have occurred, but have made it clear that they have wide-reaching social and economic implications. In light of the latter, it is obvious the rate of acceptance of technological innovations is a matter of significance for agricultural program and policy planners. All experts can well profit by prior knowledge of areas where the most rapid changes in production and marketing methods are to be expected.

This study was planned in an attempt to refine predictions related to the rate and areas of technologically-inspired changes among farmers. The nature of the research done and the methodological procedures followed necessitate that the report of findings which follows be somewhat technical in nature. However, it is felt the conclusions will be of interest to a wide range of readers, which for one reason or another, has a concern over the future of U.S. society in general or U.S. agriculture in particular.

In brief, this study attempts to predict changes and propensity to change in rural social structures. In view of the limited resources for research and the existence of limited information, the study may have wider significance, not only in the United States but also in many other societies, particularly in lesser-developed areas.

Objectives of the Study

The objectives which prompted this investigation were of both a general and a particular nature. One general goal was to determine whether or not certain characteristics of farms and farm operators reported in the regular U.S. Census of Agriculture as well as other national censuses could be used in the compilation of indexes of social change on farms. Obviously, if such data were subject to manipulation in this way, the necessity of costly field surveys would be precluded for those interested in predicting change on farms.

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[1] See for example, Adriaan K. Constandse, Pedro F. Hernandez, and Alvin L. Bertrand, *Social Implications of Increasing Farm Technology in Rural Louisiana,* Bulletin No. 628, Agricultural Experiment Station, Louisiana State University, August, 1968; and Alvin L. Bertrand and Harold W. Osborne, *Rural Industrialization in a Louisiana Community,* Bulletin No. 524, Agricultural Experiment Station, Louisiana State University, June, 1959.

The second general objective stemmed from the findings of studies which indicated a relationship between the characteristics of farm operators and their farms and change on farms. The goal was to determine whether or not certain variables, which are indicators of social change, were closely correlated with the stated characteristics.

The third objective was more specific in nature, although related to the first two objectives. It was to determine how close an association tended to exist between the size of farms and the income of farmers. One facet of this objective was to determine if size of farm and size of farm income, the independent variables, were related to a predisposition for change. No one, apparently, has attempted to test the interplay of these two specific factors. However, the question continually arises as to whether small-scale commercial family farmers with relatively high incomes are as amenable to change as large-scale farmers with relatively small incomes and vice versa.

Methodology

The data utilized for this study were part of a larger study made of the implications of technology on farms in rural Louisiana. Information was obtained from 200 farmers. These farmers resided in five parishes (counties), selected to be representative of four major crop areas in the state. The study parishes and the major agricultural enterprises which they represented were:

1. Lafourche and St. Mary parishes—sugar cane.
2. Acadia Parish—rice.
3. Tangipahoa Parish—dairying.
4. Madison Parish—cotton and soybeans.

The above study parishes were chosen in consultation with specialists from the Louisiana Cooperative Extension Service and the Louisiana Agricultural Experiment Station. The names of the specific farmers interviewed were obtained from lists provided by the county agents in each parish. Fifty farmers were chosen randomly from each of four lists. Replacement names were obtained for persons who had died or were no longer involved in farming (e.g., retired, or on other jobs). The information obtained was coded in such a way as to make possible certain statistical tests needed for the analysis.[1a]

A major source of ideas for the formulation of the study was census data relating to traits of farmers. Four major traits—size of farm, age, education, and gross income—were isolated and analyzed. Moreover, from previous field work of sociologists in Louisiana, six major aspects of social change were chosen for investigation, as follows: (1) land tenure; (2) changes in farm practices; (3) index of innovativeness; (4) index of predisposition for change; (5) estimate of acreage perceived as needed by 1980, and (6) index of level of living.

[1a] See: Constandse, A.K., P.F. Hernandez and A.L. Bertrand, *op. cit.* pp. 1-4.

The first step in the analysis was a determination of the degree of association between the items under study. This was done through use of a chi-square technique. In the second step, the significant results from the first step were tested by use of contingency coefficients (C). Finally, difference of means tests between subclasses were done using the least-squares procedure of analysis of variance.[2] Dummy variables, also known as "zero-one variables," were used for one dichotomized variable (change in tenure).[3] Three indexes were developed to simplify measures of change, namely, an index of innovativeness, an index of predisposition for change, and an index of level of living. Each is a composite score derived from values assigned to a set of attributes, attitudinal statements, or items related to level of living. Four types of change were used as a measure of innovativeness, namely: (1) number of changes made in crops produced during a 10-year period, 1957-66;[4] (2) number of changes in farm practices from 1957 to 1966;[5] (3) change to systematic business practices (bookkeeping) in the farm operation, and (4) change in the utilization of credit arrangements as a standard procedure. Each change in farm product or in farm practice was given a score or value of "one" point. A score value of "one" was also given for a move to formal bookkeeping and to more efficient use of credit. The sum of the scores of the four attributes was taken as the "index of innovativeness."[6]

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[2] For a few discussions of least-squares procedures, the reader may consult the following: Walter R. Harvey, *Least Squares Analysis of Data with Unequal Subclass Numbers,* Agricultural Research Service Publication 20-8, U.S.D.A., Beltsville, Maryland, July 1960; Palmer O. Johnson, *Statistical Methods in Research* (New York: Prentice-Hall, 1949), pp. 260-266; Sidney F. Mack, *Elementary Statistics* (New York: Holt, Rinehart, and Winston, 1960), pp. 158-162; R. E. Patterson, "The Use of Adjusting Factors in the Analysis of Data with Disproportionate Subclass Numbers," *Journal of American Statistical Association,* 41 (September, 1946), pp. 334-346; George W. Snedecor and Gertrude M. Cox, "Disproportionate Subclass Numbers in Tables of Multiple Classification," (Iowa State College Experiment Station Research Bulletin 180, 1935); Fei Tsao, "General Solution to the Analysis of Variance and Covariance in the Case of Unequal or Disproportionate Numbers of Observations in the Subclasses," *Psychometrika,* 11 (1946), pp. 107-128; and Frank Yates, "The Analysis of Multiple Classifications with Unequal Numbers in the Different Classes," *Journal of the American Statistical Association,* 29 (March, 1934), p. 51.

[3] For a discussion of "dummy variables," see: Shaul Ben David and William G. Tomek, "Allowing for Slope and Intercept Changes in Regression Analysis," Agricultural Economics Research Bulletin No. 179, Cornell University Agricultural Experiment Station, Cornell University, Ithaca, N.Y., November 1965.

Blalock treats the problem of interval scale when applied to dichotomized nominal scale as a problem of "proportions," assigning "one" or "zero" accordingly. See: H. M. Blalock, *Social Statistics* (New York: McGraw-Hill Book Co., 1960), pp. 149-151.

[4] The principal farm crops of the respondents, associated with the parishes from which they were chosen, are sugar cane, rice, dairy, beef, cotton and soybeans. However, other crops mentioned are wheat, oats, sorgum, hogs, and maize.

[5] Some examples of farm practices are the following: crop rotation; use of better pasture/grass for beef/dairy cattle; use of more or "better" fertilizer/insecticide/herbicide; change from liquid to solid fertilizer or *vice versa;* use of, or change to, better dairy machinery (e.g., bulk tank, milking machine); use of airplane for various farming operations (e.g., planting rice, spraying of insecticide); disc plowing; use of new varieties of plants; adoption of new breed of cattle; artificial insemination; cover-cropping. This list is not exhaustive of the various changes/adoptions made by farmers. It is, however, illustrative of the kind of farm practices most mentioned by farmers.

The index of predisposition for change was developed similarly. This index was made up of a set of 13 statements, each presumably tapping some attitude toward change. Each statement could be answered in one of five ways. Each possible response, designed to represent a point on a continuum, was assigned a score or point value. The point values for all 13 statements were then summed, and the total score served as an index of predisposition for change.[7] Original wording of these statements appears in Appendix B.

In the construction of the index of level of living, weights were first assigned to eight items found in farm homes or available to farm families. The items were then scored according to the weights assigned, and the sum of the items was taken as the index of level of living.[8]

Analysis and Results

Tables A-1 through A-10 in Appendix A summarize the frequency and percent distribution of each of the four characteristics and six variables. The average value of each, except for the land tenure variable, is shown in Table 1, after adjustments were made taking into consideration both data from respondents and from the census.

Tables 2 through 5 include the summaries of the relationships established between each characteristic and each variable.

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[6] For a recent discussion on the measurement of innovation, see: H.A. Presser, "Measuring Innovativeness Rather Than Adoption," *Rural Sociology*, 32, December, 1967, pp. 511-527. Presser considers innovativeness as "the propensity of an individual . . . to try and to use new and novel ideas." He says it "can be concerned with a single idea, but is *generally concerned with a number of ideas. It is a general rather than a particular concept, but is composed of unitary pieces of behavior, the indicators of the attribute*." (p. 514.) (Italics supplied.)

Lacking any information about when any of the indices of innovativeness was initially used, only crude methods were utilized in this study to develop an index. It is interesting to note, however, that the indexes of innovativeness and predisposition for change have a chi-square value of 14.48, with 6 degrees of freedom. This value is significant at the 2.5 percent level.

[7] The five possible answers to each of the 13 statements, with their corresponding value points, were as follows: for the *positively*-stated items, "strongly agree"—1, "agree"—2, "undecided"—3, "disagree"—4, and "strongly disagree"—5; for the *negatively*-stated items the point values were reversed—that is to say, "strongly disagree" was given a point value of 1. In both cases, a point value score of "1" represents the high value.

[8] The items used for the level-of-living index, with their corresponding values, were as follows: house, good repair—1; hot-and-cold water system—1; home freezer—1; one or more family cars—1; pick-up truck--1; dishwasher—2; one or more phones—2; color TV—3.

TABLE 1.—Average Values (Means) of Four Characteristics and Five Variables

Characteristics	Means[1]
Size of farm (in acres)	423.13
Age (in years)	49.84
Education (in years of schooling)	8.98
Gross income[2] (in dollars)	15,720.00
Variables[3]	
Number of changes in farming practices	1.72
Index of innovativeness	3.65
Index of predisposition for change	35.01
Estimate of acreage needed by 1980	360.00
Index of level of living	6.32

[1] The mean values were computed from sets of frequency distribution different from those found in Appendix A.

[2] Thirty-three (16.5 percent) of the respondents had gross incomes of $35,000 or more.

[3] Land tenure was excluded: 123 (61.5 percent) owned a greater part to all of their farms; 72 (36.0 percent) rented or leased a greater part to all of their farms. The remaining cases (5, or 2.5 percent) did not answer.

Size of Farm as a Predictor of Change

The total size of the farm was hypothesized to be significantly associated with each of the six variables listed in the preceding section. Table 2 shows, however, that only four indicators of change are significantly associated with the total acreage owned or operated by an individual. The variables related to total acreage are: (1) number of changes made in farming practices, (2) the farm operator's index of innovativeness, (3) the estimated acreage the farmer felt he would need by 1980, and (4) the farm operator's level-of-living index. Size of farm was not significantly associated with ownership or non-ownership of the farm, nor with the index of the farm operator's predisposition for change.

Apparently, size of farm can be used as an indicator that certain types of change will be made by the farm operator, but it will not be as good a predictor of predisposition for change and shifts in land tenure. An explanation of the above may be that operators of larger farms are more likely to see the need for and to acquire certain equipment and other items of technology than are operators of smaller farms.

TABLE 2.—Association of Size of Farm With Change Variables[1]

Indicator of change	X^2	d.f.	P
Change in land tenure (shift in ownership or rental)	3.61	2	<.20
Change in farming practices	26.16	8	<.001
Innovativeness index	23.11	12	<.05
Predisposition-for-change index	11.90	12	<.50
Estimated acreage needed by 1980	88.99	10	<.001
Level-of-living index	72.67	12	<.001

[1] In this and subsequent similar tables, the following symbols are used: X^2—Chi-square; d.f.—degrees of freedom; P—probability (level of significance).

Age of Farm Operator as a Predictor of Change

The relationships between age and the six variables in this study are shown in Table 3. It was hypothesized that age would be significantly associated with land tenure, number of changes in farming practices, index of innovativeness, and index of level of living. The basis for these assumptions was that the older farmer presumably had more time to learn about necessary adjustments on his farm, and to actually make these adjustments. The data did not support this assumption all the way, however. The only variable of change in farming which is of high significance in association with age is the number of changes made in farming practices. Another variable, index of innovativeness, is significantly associated with age. However, it appears obvious that age cannot be taken alone as a general predictor of change in farming practices.

TABLE 3.—Association of Age With Change Variables

Indicator of change	X^2	d.f.	P
Change in land tenure (shift in ownership or rental)	1.87	2	$<.50$
Change in farming practices	27.13	8	$<.001$
Innovativeness index	18.98	10	$<.05$
Predisposition-for-change index	13.88	12	$<.30$
Estimated acreage needed by 1980	14.74	10	$<.20$
Level-of-living index	15.99	12	$<.20$

A further examination of the data in Table 3 shows that farmers able to make the adjustments indicated by the six variables usually make them. Said another way, the number of changes in farming practices and the index of innovativeness are related to manipulations, such as a shift to larger machinery, etc.. Age is not the important variable in such instances.

Two indicators, as may be seen, are more closely associated with age than the size of farm. However, the direction of their association could not be determined from the available data. Such information can only be obtained from adoption studies.[9]

In view of the above findings, it may be suggested that the age of the farm operator is an indicator of change but not a predictive tool. The fact that a farmer has grown old in his occupation indicates that he has made certain adjustments in agricultural technology which allowed him to stay in business.

Education as a Predictor of Change

Education of the farm operator showed the largest number of significant associations with the six indicators of change used. As can be seen in Table 4, education is significantly associated with five of the six variables and is highly significant in four of these.

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[9] See, for example, Everett M. Rogers, *Diffusion of Innovations* (New York: The Free Press, 1962). This is an excellent summary of diffusion studies.

TABLE 4.—Association of Education With Change Variables

Indicator of change	X^2	d.f.	P
Change in land tenure (shift in ownership or rental)	5.00	2	$<.10$
Change in farming practices	32.02	8	$<.001$
Innovativeness index	39.76	12	$<.001$
Predisposition-for-change index	25.86	12	$<.02$
Estimated acreage needed by 1980	29.51	10	$<.001$
Level-of-living index	33.38	12	$<.001$

Four observations can be made from the data from which Table 4 was derived: (1) the higher the farm operator's education, the larger the number of changes he made in farming practices; (2) the higher the farm operator's education, the higher his index of innovativeness; (3) the higher the farm operator's education, the higher his estimate of acreage needed by 1980, and (4) the higher the farm operator's education, the higher his level of living. One can thus conclude that education is the best predictor of certain aspects of change among farmers in Louisiana. In this regard, it is interesting that 61 of the respondents studied were high school graduates and 31 of them had at least one year of college work. However, almost 90 percent of them believed that college training would be necessary for farming in the future.

Gross Income as a Predictor of Change

The majority of the respondents derived their income largely from their farm operations. The remainder supplemented their farm income with earnings from employment in non-farm activities.

It was assumed that gross income would be largely a function of farming operations. Thus, income was expected to be significantly related to the major indicators of change in farm operations. The data shown in Table 5 confirm this hypothesis for five of the six indicators. The exception is in the instance of the predisposition-for-change index.

Changes in farming practices were associated with gross income, but attitudes toward change were not. As stated earlier, gross income is largely a function of size of farm operations, and it has already been shown that size of farm operations is significantly associated with changes in farming practices and the index of innovativeness. Therefore, it can be concluded that income alone is not a valid predictor of change among farmers. This conclusion is based on the fact that a significant relation between income and predisposition for change was not found.

TABLE 5.—Association of Gross Income (Personal Total) With Change Variables

Indicator of change	X^2	d.f.	P
Change in land tenure (shift in ownership or rental)	6.96	2	$>.05$
Change in farming practices	26.54	8	$<.001$
Innovativeness index	39.92	12	$<.001$
Predisposition-for-change index	13.55	12	$>.30$
Estimated acreage needed by 1980	49.58	10	$<.001$
Level-of-living index	86.07	12	$<.001$

Relationships Between Characteristics of Farmers

The pattern of significant associations found between certain characteristics of farmers—size of farm, age, education, and gross income—and the indicators of change suggested that the former might also be interrelated. This inference was tested by a rotation procedure, which determined the relationships of each characteristic to all others. (See Table 6.)

TABLE 6.—Relationships Between the Characteristics of Louisiana Farmers

Characteristics[1]	X^2	d.f.	P
X_1 and X_2	–7.37	4	$>.10$
X_1 and X_3	24.19	4	$<.001$
X_1 and X_4	54.24	4	$<.001$
X_2 and X_3	–30.18	4	$<.001$
X_2 and X_4	–12.31	4	$<.02$
X_3 and X_4	31.90	4	$<.001$

[1] The notations of characteristics are as follows: X_1—size of farm; X_2—age; X_3—education; X_4—gross income.

The following observations can be made in light of the analysis done: (1) size of farm and education are directly associated; (2) size of farm and gross income are directly related; (3) age and gross income are inversely related, and (4) education and gross income are directly related. It can be inferred from these observations that the younger farmers have higher education, higher gross income, and, probably, larger farm operations. Age has thus been shown to be least related both to the other characteristics and the indicators of change, and is not by itself an adequate basis for understanding them. On the other hand, farm size and gross income are most highly associated.

Up to this point, the analysis has centered upon associations between the characteristics of farmers and the indicators of change used and upon the inter-relations of individual characteristics. In order to further analyze the data, two of the characteristics of farmers were chosen and related simultaneously with each of the indicators of change. The characteristics selected were size of farm operations and gross income.

Effect of Size of Farm and Gross Income on the Indicators of Change

Size of farm operations and gross income were examined together in greater detail to analyze their combined relationship to the change indicators. Because of the nature of the relationship between these two characteristics, they tend to have an effect in a similar direction. For the number of changes in farming practices, the index of innovativeness, and the level of living, the relationship is simple. Both characteristics have a direct effect. With a larger farm size and higher income, the number of changes made in farming practices increases, and a farmer of this kind can be expected to be innovative. It is not unexpected that both characteristics influence level of living, since this index is a function of the number, kind, and quality of possessions of farm operators, and these are largely determined by income. Income, in turn, is highly influenced by size of farm. This association indicates that the larger the size of the farm, the higher the gross income, and the higher the level of living, as was hypothesized. On the other hand, neither farm size nor income are related to predisposition for change. Land tenure is an exceptional case since size of farm has no effect, but gross income does have an effect on land tenure.

For the estimate of acreage needed the relationship is more complex. Farm size has a direct effect, but the effect of income is apparent only within particular farm size groups. That is to say, income is not a direct predictor of the over-all pattern of acreage perceptions, but for any of the farm size groups, knowledge of income levels within that farm size group increases the ability to predict perception of acreage needs.

These conclusions are based on the results of an analysis of variance, using least squares procedures, which are presented in Tables C-1 through C-6 in Appendix C. As in the previous discussion, the .05 percent level of significance was used.

Implications

The findings of this study suggest that, of the four characteristics examined, size of farm and education are the best indicators as to whether farm operators are likely to adopt changes over a period of time. This result is of considerable significance for those charged with the task of planning strategies for induced change in agricultural areas. Through utilization of data which the U.S. Census of Agriculture regularly collects, it can be predicted which farmers and which areas will likely adopt new items of technology more quickly. Heretofore, it has been thought necessary to conduct costly and time-consuming field studies to acquire this type of information. Knowledge of either of these characteristics—size of farm or education—would be sufficient to predict where relatively rapid adoption of change items could be expected to occur.

Appendix A

TABLE A-1.—Size of Farm Operated by Respondents

Size of farm	Number	Percent
Below 101 acres	59	29.5
101 to 300 acres	78	39.0
Above 300 acres	63	31.5

TABLE A-2.—Age of Respondents

Age in years	Number	Percent
Below 41 years	40	20.0
41 to 55 years	88	44.0
Above 55 years	72	36.0

TABLE A-3.—Education of Respondents

Number of years of schooling	Number	Percent
Below 6 years	56	28.0
7 to 11 years	75	37.5
Above 11 years	61	30.5
DNA (did not answer)	8	4.0

TABLE A-4.—Gross Income of Respondents

Income	Number	Percent
Below $6,000	68	34.0
$6,000 to $19,000	71	35.5
Above $19,999	61	30.5

TABLE A-5.—Land Tenure Characteristics of Respondents

Tenure	Number	Percent
Owns greater part of all land	123	61.5
Rents/leases greater part of all land	72	36.0
Other forms of arrangements	5	2.5

TABLE A-6.—Number of Changes in Farm Practices Made by Respondents During the Decade 1957-1966

Number of changes	Number	Percent
No changes made	46	23.0
One change made	50	25.0
Two changes made	50	25.0
Three changes made	28	14.0
Four to six changes made	26	13.0

TABLE A-7.—Index of Innovativeness of Respondents

Index of innovativeness (in score-points)	Number	Percent
No score-point	2	1.0
One score-point	17	8.5
Two score-points	43	21.5
Three score-points	39	19.5
Four score-points	46	23.0
Five score-points	22	11.0
Six score-points	14	7.0
Seven to nine score-points	17	8.5

TABLE A-8.—Index of Predisposition for Change of Respondents

Index of predisposition (in score-points)	Number	Percent
24 to 29 score-points	20	10.0
30 to 32 score-points	33	16.5
33 to 35 score-points	48	24.0
36 score-points	22	11.0
37 to 38 score-points	33	16.5
39 to 40 score-points	21	10.5
41 to 45 score-points	20	10.0
DNA (did not answer)	3	1.5

TABLE A-9.—Estimated Minimum Acreage Perceived Necessary in 1980 by Respondents

Estimated acreage	Number	Percent
10 to 100 acres	31	15.5
100 to 150 acres	19	9.5
151 to 200 acres	32	16.0
201 to 300 acres	13	6.5
301 to 500 acres	28	14.0
Above 500 acres	77	38.5

TABLE A-10.—Index of Level of Living of Respondents

Index of level of living (in score-points)	Number	Percent
One to three score-points	19	9.5
Four score-points	30	15.0
Five score-points	43	21.5
Six score-points	20	10.0
Seven score-points	39	19.5
Eight to nine score-points	20	10.0
Ten to twelve score-points	29	14.5

Appendix B

Predisposition Toward Selected Aspects of Change

1. Strongly agree.
2. Agree.
3. Undecided.
4. Disagree.
5. Strongly disagree.

1. Farming, in general, has improved within the past 10 years.
2. Farmers are more independent in their operations than they were 10 years ago.
3. A farmer who can earn 20 percent more outside of agriculture, working for someone else, should take the job.
4. If his son who has the opportunity to take over his farm approaches a farmer about taking a non-agricultural job, the farmer should advise him to do so.
5. A successful farmer these days needs a college education in agriculture.
6. Farming is a science, requiring a high degree of technical training on the part of the farmer.
7. Many of the new farming ideas that come out these days are not practical for the average farmer.
8. There is no substitute for practical experience in farming.
9. It is more important for farmers to make decisions on the basis of habits and rules of thumb than to try to find out new ways of doing things.
10. A farmer can obtain better information from magazines and research bulletins than from relatives, neighbors and friends.
11. Most farmers spend too much time and effort trying to keep themselves up to date in agriculture.
12. Time spent by the farmer in finding out about new ideas and practices in farming is time well spent.
13. The major objective in farming is profit to the farmer.

Appendix C

TABLE C-1.—Least-Squares Analysis of Variance for the Size of Farms and Gross Income as They Affect Land Tenure (Shifts of Ownership and Rental)

Source	d.f.	Sum of squares	Mean square	F*	P*
Total	195	123.000			
Total size	2	.915	.457	2.024	n.s.
Total income	2	1.785	.892	3.950	.025
Total size x income	4	.872	.218	.964	n.s.
Total remainder	186	42.034	.226		

*In this and subsequent similar tables, the following symbols are used: F—the variance ratio; P—probability (level of significance), n.s.—not significant.

TABLE C-2.—Least-Squares Analysis of Variance of the Size of Farm and Gross Income in Relation to Changes in Farming Practices

Source	d.f.	Sum of squares	Mean square	F	P
Total	200	1061.000			
Total size	2	18.524	9.262	4.794	.01
Total income	2	17.325	8.662	4.484	.025
Total size x income	4	3.926	0.982	0.508	n.s.
Total remainder	191	368.997	1.932		

TABLE C-3.—Least-Squares Analysis of Variance of Size of Farm and Gross Income on Index of Innovativeness

Source	d.f.	Sum of squares	Mean square	F	P
Total	200	3347.000			
Total size	2	18.788	9.394	3.126	.05
Total income	2	27.750	13.875	4.617	.01
Total size x income	4	7.202	1.802	0.599	n.s.
Total remainder	191	573.988	3.005		

TABLE C-4.—Least-Squares Analysis of Variance of Size of Farm Operations and Gross Income on Index of Predisposition for Change

Source	d.f.	Sum of squares	Mean square	F	P
Total	197	2598.000			
Total size	2	2.166	1.083	0.632	n.s.
Total income	2	2.329	1.164	0.679	n.s.
Total size x income	4	1.572	0.393	0.229	n.s.
Total remainder	188	322.518	1.716		

TABLE C-5.—Least-Squares Analysis of Variance of Size of Farm Operations and Gross Income on Estimated Acreage Needed by 1980

Source	d.f.	Sum of squares	Mean square	F	P
Total	155	2565.000			
Total size	2	82.321	41.161	19.944	.001
Total income	2	0.472	0.236	0.114	n.s.
Total size x income	4	38.022	9.505	4.583	.025
Total remainder	146	302.827	2.974		

TABLE C-6.—Least-Squares Analysis of Variance in the Relation of Size of Farm and Gross Income on Index of Level of Living

Source	d.f.	Sum of squares	Mean square	F	P
Total	200	4799.000			
Total size	2	33.558	16.779	4.795	>.01
Total income	2	121.988	60.994	17.429	>.001
Total size x income	4	10.579	2.644	0.756	n.s.
Total remainder	191	668.409	3.500		

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Attitudinal Patterns Prevalent in A Forest Area With High Incendiarism

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IN COOPERATION WITH
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FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

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Preface

This bulletin represents a continuation of cooperative research efforts sponsored by the Fire Prevention Research Project, Southern Forest Experiment Station of the United States Forest Service, and the Department of Rural Sociology at Louisiana State University. The work on this particular project also involved close cooperation with the Louisiana Forestry Commission.

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Attitudinal Patterns Prevalent In a Forest Area With High Incendiarism

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Introduction

The efforts of the Southern Forest Experiment Station and of the various Forestry Commissions in southern states directed toward the reduction of forest incendiarism are well known. These efforts have included research designed to shed light on the social factors related to deliberately set forest fires so that programs could be initiated to change these behavior patterns. The study reported here falls in this category. It is the latest in a series of investigations of this nature. Previous projects have determined the reasons fires are deliberately set, the demographic characteristics of persons residing in areas with high fire rates, the effectiveness of forest and other agencies in communicating fire prevention messages, and the roles of local opinion leaders in the communication of fire prevention messages.[1]

The information obtained from the above-mentioned studies provided the inspiration for this one. Basically, the idea was to probe in depth the attitudes and beliefs relating to a "fire culture" in an area with high forest fire rates before a program of change was implemented. In other words, a "benchmark" needed to be established in order to measure the success or failure of fire prevention programs. Such a program has, in fact, been inaugurated in the study area, and its success or failure will be measured in terms of changes in attitudes and beliefs as well as in terms of the incidence of non-prescribed fires. The results obtained will be reported at a later date. The findings presented in this bulletin are offered as background information for persons and agencies now engaged in planning programs of forest fire prevention and forest conservation.

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[1] Thomas Hansbrough, *A Sociological Analysis of Man-Caused Forest Fires in Louisiana* (Unpublished Ph.D. dissertation, Baton Rouge, Louisiana, Louisiana State University, August, 1961). M. Lee Taylor, and Alvin L. Bertrand, *Some Human Factors in Woods Burning*, Louisiana Agricultural Experiment Station Bulletin No. 601 (Baton Rouge: Louisiana State University and Agricultural and Mechanical College, 1965). B. Eugene Griessman and Alvin L. Bertrand, *Factors Related to Communication of Forest Fire Prevention Messages*, Louisiana Agricultural Experiment Station Bulletin No. 623 (Baton Rouge; Louisiana State University and Agricultural and Mechanical College, 1967). Ben E. Dickerson and Alvin L. Bertrand, *Potential Roles of Local Opinion Leaders in the Communication of Forest Fire Prevention Messages*, Louisiana Agricultural Experiment Station Bulletin No. 639 (Baton Rouge: Louisiana State University and Agricultural and Mechanical College, 1969).

Objectives of the Study

The over-all objective of this study was, as indicated, to determine certain attitudes and beliefs of persons living in an area with a history of high rates of forest incendiarism. Persons charged with the development of forest fire prevention programs obviously will be in a much better position to plan effectively with information on how persons in firesetting communities think about the uses of and needs for fire. The specific aims of the study were threefold:

1. To determine the attitudes and beliefs of persons in an area of high forest incendiarism toward forest conservation. This type of information was considered fundamental to any program of education which might be designed. Logically, individuals who hold positive ideas about forest conservation are less likely to do things detrimental to wooded areas. Persons who are not concerned about conservation of forests represent a different and more difficult target group and other types of educational approaches must be planned for them. The matter of fire prevention thus becomes one of convincing the latter group that such practices are harmful.

2. To determine the attitudes and beliefs of persons in high incendiarism areas toward forest agencies and their personnel. Several studies have determined that people in "fire" areas are somewhat alienated from government agencies as a whole. They tend to question both the need for and intentions of the agencies. However, very little information is available on the significance for action programs of the feelings of a client public about individual government agencies. In this regard, it was surmised that a given program might succeed or fail because of feelings about its personnel and operational procedures. It was thus felt of importance to determine the feelings of the residents of a "fire" area about publicly supported agencies.

3. To determine whether or not incendiarism represented a definite subculture within the local community. In this connection, it is known that often certain behavior patterns are not interpreted as illegal by individuals or groups, even though they are against the law. When this is true, there is little local sanction against these acts, because they are considered normal. To the extent that a relatively large group behaves in this way, a subculture can be said to exist. Again, this is a pattern of behavior which was seen as having basic significance for planners of fire prevention programs.

Description of Study Area and Methodology

The study area selected is located in western Louisiana and includes some 60,000 acres. Reforestation efforts during the past 15 years have converted a large percentage of this acreage into pine plantation, and the area is now approximately 85 percent forest land. A little over 50 percent of the total area is owned by large companies. Absentee ownership, created by landowners living out of the area, accounts for about 33 percent (20,500 acres) of the remainder of the land and leaves approximately 7,500 acres in resident ownership. About one-half of local residents own cattle and there is some "open range" grazing on the land of absentee landowners and large companies. The two leading crops in the area are soybeans, which have increased considerably during the past few years, and watermelons.

The parish (county) within which the study area is located has been designated a "hot spot" by the Louisiana Forestry Commission. It is one of the seven parishes which have accounted for up to two-thirds of the incendiary fires within the state in the past few years. The study area itself is one of the main high-fire-occurrence localities within the state.

The area chosen for intensive study did not include a large number of families. The largest concentration of residences did not include over a dozen homes. It was some 15 miles from the nearest town and approximately 50 miles from a fairly large population center.

The low density of population made it possible to include every household head in the area in the study group. Each household head was interviewed and asked questions related to: (1) the socio-economic characteristics of his family; (2) his social participation characteristics; (3) the local persons whom he thought were influential and socially powerful; (4) his voting behavior; (5) his contacts with government agencies and corporations; (6) his visiting patterns, and (7) his attitudes about certain relevant issues.

The somewhat sensitive nature of the questions posed and a traditional reluctance on the part of area residents to accept strangers made it expedient to use local people for interviewers. Eight individuals were employed from a town 15 miles west of the study area. These individuals were trained in interviewing techniques and briefed on the use of the interview schedule which had been prepared. Each interview took about 40 minutes to complete and a total of 259 interviews were completed.

General Characteristics of the Study Population

Over 85 percent of the heads of households interviewed owned their homes and/or farms. Although almost all respondents had land, 84 percent owned or rented less than 100 acres. Two out of five lived on 10 acres or less. Only 12 persons had more than 200 acres. Despite their rural residence, farming was not a commercial venture for most of the family heads in the study area. Only nine persons reported that all their family income was from farming. An equal number received from 50 percent to 75 percent of their total income from agricultural activities. In contrast, almost 83 percent of the persons interviewed reported no farm income.

Since it was known that a major reason given for burning the woods was to improve grass for cattle grazing, the respondents were asked if they owned cattle. Some 134 persons (52 percent of the respondents) claimed to have one or more head of cattle. About half of these individuals said they owned 10 or more head and one-third of them admitted that their stock grazed on the open range.

There was a wide range in the ages of heads of households—20 to 93 years—but the median age was 53 years. This indicated that the age composition of the population was not unlike that found in other rural areas of the state.

The number of years of school completed by heads of households ranged from none (two persons) to 18 years (one person). About half (48 percent) of the heads of households had completed less than the eighth grade, while over two-fifths (43 percent) had attained a grade level from the ninth grade through high school graduation. Only 4 percent had college experience.

Responses to questions related to religious preference showed that over two-thirds of the respondents were Baptist. The next largest denominational group were members of the Pentescostal Church (16 percent). The remainder of the heads of households were dispersed among various religious groups, primarily Protestant.

Over two-fifths (42 percent) of the interviewees reported family income below the poverty level; i.e., less than $3,000. About two-thirds (65 percent) of them said their family income was below $5,000. Only 4 percent reported family incomes of $10,000 or more. Interviewees' statements indicated that the net worth of their families varied from less than $5,000 to $70,000. However, three-fourths of them reported that their total net worth was less than $20,000.

The population under study was not characterized by a high degree of participation in formal organizations, except the church. Membership affiliation was claimed in farm related organizations as follows: Farm Bureau, 11.2 percent; breeders associations, 5.0 percent; Watermelon Association, 5.4 percent; Cattlemen's Association, 3.5 percent; Louisiana Forestry Association, 0.4 percent and Soil Conservation Service, 9.7 percent. Of the 81 persons belonging to the above groups, 26 attended no meetings of the organizations they belonged to during the year and only 10 persons attended at least three-fourths or more of the meetings held. About 26 percent of the heads of households held a membership in a fraternal organization, such as the Masons, and 10 percent belonged to a civic organization, such as a Kiwanis club.

Each respondent was asked to name persons whom he felt were influential in the local area in an attempt to learn who might be important in molding attitudes and feelings. The person most often mentioned was an elected official (64 respondents). Others mentioned included three ministers, two high school teachers, one farmer, another elected official, one grocery store owner-operator, one elementary school teacher, and one electric company employee.

All respondents were asked questions about their personal contacts with the representatives of large landholding companies, the Louisiana Forestry Commission, and the Louisiana Cooperative Extension Service. The questions referred to contacts made within the last two years. In response to the query regarding whether or not they had talked with a representative of one of the four large paper companies operating in the area, the overwhelming response of household heads was "no." Only one in five had talked with or had dealings with persons representing these large landholders. A much larger number, some 51 percent, had been in contact with Louisiana Forestry Commission representatives. This was explained in terms of requests for help in fire supression and timber management as well as casual meetings.

Less than half of the respondents had had personal contact with a representative of the Cooperative Extension Service. About two-fifths of them said they had talked with the county agent or his associates about farm or other problems.

All in all, the families in the study area appear to be more or less representative of residents in other places where forest fires are common occurrences. Their attitudes and feelings toward conservation and fire prevention agencies should be more or less typical and can be placed in the perspective of their characteristics outlined above. These attitudes are described in the following section.

Respondents' Attitudes Toward Forest Conservation

It is often difficult to get an interviewee to forthrightly express feelings about issues which have some element of controversy, or about which mixed feelings exist. For this reason, an indirect approach to the determination of attitudes towards forest conservation and forestry agencies was used. Rather than ask each of the household heads interviewed pointblank about his views on what might be a sensitive issue, each was asked to react to a series of statements which related to the theme in mind. In this connection leading words, such as "conservation," were not mentioned in these statements because of the clues for answering which might be given. Respondents were given a choice of five answers to each of the statements prepared: "I strongly agree", "I agree", "I disagree", "I strongly disagree", "I have no opinion." The response selected indicated not only the nature of the attitude held, but the intensity of the feeling harbored by the individual.

The seven statements used to test for attitudes toward forest conservation appear in Table 1. Reactions of heads of households to each are briefly summarized below.

Respondents Generally Felt Forests Are Important to the Local Economy.—It can be seen in Table 1 that over three-fourths of the heads of households interviewed agreed with the statement (one-fourth

TABLE 1.—Responses of Interviewees to Statements Related to Forest Conservation

Statements	Percentage distribution of responses (N=259)					
	I strongly agree	I agree	I disagree	I strongly disagree	I have no opinion (don't know)	No response
The future of the area economy lies largely in the development of forests.	25.9	56.7	10.4	2.7	3.1	1.2
Putting money into trees is a poor investment.	10.0	22.8	36.3	28.2	1.2	1.5
Only land fit for nothing else should be used for growing trees.	17.0	42.4	22.4	14.3	2.7	1.2
Burning the woods reduces the number of bugs, snakes, and other pests.	22.4	50.6	13.9	7.7	2.3	3.1
Most of the woods around here look all grown up because they don't burn them often enough.	10.0	29.7	29.7	22.4	3.9	4.3
Firing the woods is an established custom that ought not be regulated by law.	4.6	6.2	40.9	42.1	3.5	2.7
If a man thinks woods burning is the thing to do, he should be allowed to do it regardless of who owns the land.	0.8	2.3	41.7	51.7	1.2	2.3

strongly agreed) that the future economy of the local area was closely tied to the development of forests. This type of response indicates an awareness of the value of forests in an otherwise relatively unproductive region and implies a positive attitude toward conservation. It is in contrast to the negative feelings expressed or implied by about 16 percent of the interviewees. The latter percentage is high enough to warrant some concern on the part of planners for fire prevention programs, since only a small percentage of inhabitants engage in systematic fire setting. The over-all significance of an active minority will be discussed in a later section of this report. Here, the importance of a widespread feeling of dependence on forest resources cannot be overstressed. Such an attitude is basic in that it provides a departure point for fire prevention efforts.

Majority of Respondents Felt Planting Trees Was a Good Investment.—One way to determine a person's attitude toward forest conservation is to determine whether he looks upon trees as a good investment. Approximately two-thirds of the persons interviewed either agreed (36 percent) or strongly agreed (28 percent) with the idea that trees did represent a way to earn money. However, it is perhaps as important, if not more so, that one out of three of the respondents felt that the person planting or growing trees was making unwise use of his money. To the extent that such an attitude is present, it suggests that conservation practices will be minimized. It also indicates that efforts will be made to convince others that their land can be put to a better use than the growing of trees. It is of interest that a somewhat smaller percentage of the interviewees felt that trees were a good investment than felt that the future of the local economy was related to forest resources. This apparent incongruity is probably explained by the fact that some respondents were convinced that other enterprises represented a wiser investment, but could not see a turn away from forests.

Most Respondents Felt Trees Should Be Grown on Marginal Land.—In an attempt to probe more deeply into the respondents' feelings about conservation, each of them was asked to react to the statement that trees should only be grown on land not fit for agricultural purposes. It is a revealing commentary on local understanding and feeling that three out of every five interviewees felt that trees should be reserved for land not usable for crops or pastures. How such a reaction should be interpreted in relation to conservation is, perhaps, debatable. However, there is an obvious implication that individuals holding such a view do not place as high a value on trees as they do on other agricultural enterprises. Therefore, one could logically assume that this attitude is somewhat of a deterrent to forest conservation practices.

Most Respondents Felt Burning the Woods Reduced Bugs and Other Pests.—One reason commonly given for burning woods areas is that fire gets rid of undesirable insects and other pests. The relation of such a view to conservation is inherent in the hazards which unprescribed burning presents to woodland. In this light, it is most interesting that almost three-fourths of the respondents agreed with the statement that fire reduced the incidence of bugs and snakes. Regardless of the validity of such a belief, it is clearly held widely enough to have some implications for fire prevention programs which, of course, relate directly to forest conservation.

Many Respondents Felt Burning Improved the Looks of the Countryside.—One might wonder whether a sense of the aesthetic would override notions of conservation. While such a question is probably imponderable, except in some specific cases, it could certainly have a bearing on conservation programs. With this thought in mind, all respondents were asked if they felt the woods around them looked overgrown when they were not burned often enough. Three out of 10 respondents admitted to such a feeling. For this group, it is apparent that fire had the effect of improving the looks of the countryside. It is implicit in this view that a "clean" countryside is more important than the conservation damage which might be done. Although the number of respondents expressing this opinion did not constitute a majority, it was large enough to be of importance in planning programs of forest conservation and fire prevention.

Most Respondents Felt Woods Fires Should Be Regulated by Law.—It is of interest to both planners and conservationists that an overwhelming number of the heads of households interviewed felt that woods burning should be regulated by law. This attitude is one which is often thought not to exist in places with high incendiary rates. The fact that 83 percent of the respondents agreed that it was proper to regulate the setting of fires by law indicates a general appreciation of the damage which fire can do. Of course, the question arises as to whom this law should apply to and who should be responsible for its enforcement. Nevertheless, such a feeling can be construed as a positive force for conservation.

Very Few Respondents Felt Individuals Should Be Free to Burn Others' Woodland.—Much of the woodland burned by incendiarists does not belong to them. This is a practice which dates back to the days of the widespread open range. For this reason, it was considered appropriate to ask those interviewed if they felt it was right for persons to burn the woodland of others, just because they felt it needed burning. The overwhelming negative response was again a commentary on the fact that many of the norms of the greater society have been internalized in the local area. Just 3 percent of the interviewees felt that such a practice was right and should be condoned. The remainder were of the opinion that an owner's permission should be obtained before his woodland was burned. This pattern of responses not only indicates an attitude favorable to conservation, but also demonstrates a respect for private property. Both these attributes can be taken advantage of in planning fire prevention campaigns.

Over-all, A Moderate Conservation Orientation Was Found in the Study Area.—The preceding discussion has shown that respondents reacted to the seven statements relating to conservation in different ways—some were strongly or moderately positive, while others were negative to varying degrees. Obviously some method of summarizing the various responses was needed in order to obtain an over-all assessment of feelings toward conservation. Of the several statistical techniques available for solving this type of problem, the Guttman technique was considered most appropriate. This procedure is specifically designed to test for internal consistency in the responses to batteries of questions relating to a given issue or phenomenon. The scale pattern for the responses obtained is shown in Table 2. A coefficient of reproducibility (the measure of internal consistency) of 0.9090 was obtained. This is considered high enough to claim scalability for the various statements. Said another way, if an interviewee responded in a given way to a statement, it could be predicted within the limits of reproducibility that he would react to the remaining statements in a consistent manner.

TABLE 2.—Distribution of Orientation Toward Conservation Scale Types

Scale	Scale items							Respondents	
types	6	1	7	2	5	3	4	Number	Per cent
1								4	1.54
2	X[1]							10	3.86
3	X	X						16	6.18
4	X	X	X					40	15.44
5	X	X	X	X				57	22.01
6	X	X	X	X	X			48	18.53
7	X	X	X	X	X	X		50	19.31
8	X	X	X	X	X	X	X	34	13.13
Total								259	100.00

[1] X denotes agreement.

The columns to the right in Table 2 show the number and percentage of respondents whose answers were consistent for a given number of the statements used. Scale types 6, 7 and 8 can be considered to include those individuals with a relatively strong conservation orientation. It can be seen that these classes consist of slightly over half of the respondents. This is a sufficient number to conclude that there is at least a moderate orientation toward conservation in the study area. It is of consequence, however, that over-all there was a considerable negative or neutral attitude toward conservation of forests. This point will be elaborated upon in the concluding section of this report.

Respondents' Attitudes Toward the State Forestry Commission

It was pointed out in the introduction that the attitudes of residents in forested areas toward representatives of forestry agencies and toward the agencies themselves were considered a relevant factor in the potential success of fire prevention programs. It was for this reason that a battery of statements was prepared, as a companion series to the conservation statements, to test attitudes toward forestry-related persons and agencies. The responses to these statements are summarized below.

Respondents Had Mixed Feelings About the Contribution of the Forestry Commission to Small Farmers.—The dispersion of respondents' responses to statements relating to their feelings about the state forestry commission and its personnel is shown in Table 3. It can be seen that a considerable number of them, well over two-fifths, agreed with the assertion that the small farmer derived little or no benefit from forestry programs. This number is large enough to indicate a substantial lack of faith in such agencies. The question which arises is, "Why"? One could speculate on the one hand that such agencies have not concerned themselves with the small farmer, and on the other that the programs sponsored have not been considered of use by such farmers. Whatever the reason, there is a clue in the above pattern of responses that the efforts of government employed foresters are not highly appreciated.

Respondents Felt Forestry Commission Representatives Were Sincere in Their Efforts.—It is somewhat surprising, in light of the response to the preceding statement, to discover that the large majority of respondents felt that representatives of the state forestry commission were sincere in their efforts to assist people. Some 93 percent of the heads of households interviewed expressed such a view. The preponderance of this response leads one to feel that the persons interviewed were not antagonized by forestry commission personnel, but simply did not feel they had the right programs for them. Again, this is a discovery which should have implications for program developers in this agency as well as others. It indicates that representatives of the Louisiana Forestry Commission would at least have an entree for implementing desired programs.

Respondents Generally Believed the Forestry Commission Was Fair in Its Hiring Practices.—Forest service agencies have occasion to hire local people in connection with the implementation of certain programs, such as those related to the planting of trees and fire fighting. It is not unusual that feelings of discrimination develop in such cases, especially when there is competition for the jobs available. These feelings, whether or not they are valid, are an important aspect of the relations between local people and the agencies. The fact that the heads of households interviewed did not generally feel that the hiring practices of the

TABLE 3.—Responses to Statements Related to State Forestry Commission and Its Personnel

Statements	Percentage distribution of responses (N=259)					
	I strongly agree	I agree	I disagree	I strongly disagree	I have no opinion (don't know)	No response
The small farmer does not benefit (gain) from the service of the forestry commission.	8.1	34.3	39.4	13.1	3.9	1.2
Persons representing the forestry commission are sincere in attempting to assist the people in this community.	32.4	60.6	2.3	0.8	3.1	0.8
The forestry commission is unfair in its hiring practices.	3.5	5.4	39.8	24.6	23.2	3.5
The forestry commission always rebuilds the fences it cuts in the process of fighting a fire.	17.8	38.6	13.1	4.2	23.6	2.7
If it were not for the high number of forest fires in the area, forestry commission personnel would have nothing to do.	7.7	22.0	36.7	20.5	10.8	2.3
Except for two or three months of the year the forestry commission personnel do not do enough work to justify their salaries.	5.4	14.7	37.8	28.2	11.6	2.3
Do you feel the forestry commission should do more than it is presently doing?	0.0	14.7	77.2	0.0	0.0	8.1

forestry commission were unfair—about two-thirds of them disagreeing with such a position—is significant. It cannot be overlooked, however, that 9 percent felt that the agency was discriminatory. Although the above responses must be interpreted in the light that one-fourth of the individuals did not feel they had a basis for making a decision, there appears enough evidence to assume a good local employment image exists for forest agencies.

Respondents Were Divided in Opinion as to How Systematic the Forestry Commission Was in Repairing Damage Done While Fighting Fires.—One facet of the public relations problems of fire fighting agencies is maintaining rapport with people whose property must be used or damaged in fire fighting efforts. Sometimes fences have to be cut so that vehicles can be moved quickly to the scene of a fire, and often firebreaks must be created. For this reason each respondent was asked to indicate whether or not he felt the forestry commission was careful to repair fences damaged while fighting fires. Approximately one-fourth of the persons interviewed did not feel they had enough information to form an opinion on this matter. Of those who did express an opinion, approximately one-third were convinced the forestry commission was neglectful in rebuilding cut fences. These findings indicate that there is considerable mixed feeling in the community on this score. It seems likely that repairing fences cut during fire fighting is one type of strategy which could be practiced to enhance goodwill toward forest agencies.

Some Respondents Felt Fire Fighting Represents the Sole Work of Forestry Commission Personnel.—One statement reportedly heard in communities with high fire rates is that fire fighting represents the only work for forest agency personnel. When such statements are made, there is often an implication that fire prevention is not pushed because the success of such programs would make the maintenance of forest agency personnel unnecessary. In response to queries on this point, three of every 10 of the heads of households made comments indicating general agreement with this notion. While this is not a majority, it is a high enough number to warrant the attention of agency representatives. It definitely indicates the need for better orientation of local people.

Some Respondents Felt Forestry Personnel Seldom Did Enough Work to Justify Their Salaries.—In most rural communities there is a widespread feeling that government workers have soft jobs. In fact, many times there seems a strong impression that the salaries paid such workers are not justified. For this reason, each of the interviewees was asked if he felt forest agency personnel did enough work to justify their salaries. About 20 percent of them answered this question in a negative sense, implying that they felt such employees were "deadheads" most of the time. Again, this is not a majority, but it is a high enough percentage to indicate a rather well diffused erroneous notion of the job demands of forest agency workers. There is no doubt that an educational program designed to improve the image of the employees of forest agencies needs consideration, if a better local image is desired.

Most Respondents Felt the Forestry Commission Was Doing About All It Could Be Expected to Do.—It appears somewhat of an incongruity that some persons felt that forest agency personnel were not earning their keep while others thought they were doing about all they could be expected to do. Probably these variant responses were not given by the same individuals. In any event, they indicate that certain respondents saw the role of and need for foresters in a different light. About three out of every four interviewees agreed that the forestry commission was doing what should be done. Fifteen percent disagreed. These persons were asked to elaborate on what forestry personnel might do to keep busy. Some of the things which could be done, according to the interviewees, were to plow more fire lanes, to work faster while on their jobs, to provide protection for the "little man" as well as the large landholder, and to spend more time apprehending fire-setters. Some of these matters are beyond the jurisdiction of forest agencies, but they indicate the degree of misinformation which is held in local communities as well as some needs which residents feel.

In General, Respondents Were Favorably Disposed Toward the Forestry Commission.—The responses to the seven statements relating to attitudes towards the forestry commission were statistically summarized in the same manner as responses to statements relating to conservation. When neutral responses were allocated randomly to positive and negative responses, the coefficient of reproducibility was raised to the acceptable level of 0.93105. Again summing the percentage of interviewees falling in scale types 6, 7 and 8, it can be seen in Table 4 that about 70 percent of the respondents held basically positive attitudes toward the forestry commission. This finding is one which should be reassuring to those who have wondered about the image of forest agencies and their representatives in areas of high incendiarism.

TABLE 4.—Distribution of Disposition to Agency Scale Types

Scale	Scale items							Respondents	
types	2	3	7	4	6	5	1	Number	Per cent
1								5	1.93
2	X[1]							10	3.86
3	X	X						8	3.09
4	X	X	X					26	10.04
5	X	X	X	X				33	12.74
6	X	X	X	X	X			22	8.49
7	X	X	X	X	X	X		51	19.69
8	X	X	X	X	X	X	X	104	40.16
Total								259	100.00

[1] X denotes agreement.

Respondents' Attitudes Indicative Of A Subculture Of Incendiarism

Subcultures of one type or another can be found in most communities. These are simply "pockets" or "islands" of people who practice some sort of behavior which is different from what is done by the remainder of the population. For example, certain religious groups stand out because of their beliefs, and teen-agers are usually conceded to have manners of communicating and social practices which set them apart. In planning for this study, it was hypothesized that the incendiarists in the community would represent a subculture definitely recognizable in terms of attitudes, visiting patterns, and social participation. The findings related to this hypothesis are presented in this section.

Only Nine Respondents Classifiable as Latent Incendiarists.—Three statements interviewees were asked to respond to were designed to indicate the "norms" or attitudes supported by respondents regarding setting fire to the woods. These three statements were:

1. Persons who intentionally set woods fires on other people's land should be prosecuted as criminals.
2. Firing the woods is an established custom that ought not be regulated by law.
3. It is all right for an individual who has cattle which graze on land owned by an absentee landlord to burn the woods to improve the grazing, if the landlord does nothing with his woods.

From Table 5 it can be seen that 10.5 percent of the study population disagreed with the first statement, 10.8 percent agreed with the second statement, and 13.6 percent agreed with the third statement. Said

TABLE 5.—Responses to Three Normative Statements Related to Setting Woods Fires

	Agree		Neutral		Disagree		No response		Total	
Statements	N	%	N	%	N	%	N	%	N	%
Persons who intentionally set woods fires on other people's land should be prosecuted as criminals.	(220)	85.0	(4)	1.5	(27)	10.5	(8)	3.0	(259)	100
Firing the woods is an established custom that ought not be regulated by law.	(23)	10.8	(9)	3.5	(215)	83.0	(7)	2.7	(259)	100
It is all right for an individual who has cattle which graze on land owned by an absentee landlord to burn the woods to improve the grazing if the landlord does nothing with his woods.	(35)	13.6	(8)	3.0	(207)	79.9	(9)	3.5	(259)	100

another way, at least 80 percent of the study population were of the same mind in their reaction to each of the statements. Those persons who gave minority responses were deemed to deviate from normative patterns in the community.

A scrutiny of individual responses to the three statements showed that six respondents were "deviants" on each of the three items. In addition, three respondents indicated at least one deviant response and at least one neutral response without giving a "conforming" response on a single item. These nine respondents were grouped into a category labeled "latent incendiarists." (See Table 6.) In contrast, 170 respondents (66 percent) agreed on each of the three statements. These persons were identified as "conformists." Four respondents had to be omitted from the analysis as they did not answer any of these questions. The remaining 76 respondents (29 percent) who gave deviant responses on some items but normative responses on others were classified as "marginals." At this point, it should be made clear that there was no way of actually determining whether or not an individual was an incendiarist. Classification as a latent incendiarist simply indicates an expression of attitudes conducive to woods burning.

TABLE 6.—Number and Percent of Persons Categorized as Conformists, Marginals, and Latent Incendiarists

Category	Number	Percent
Conformists	170	66
Marginals	76	29
Latent incendiarists	9	3
No response	4	2
Total	259	100

According to Louisiana laws, anyone who is apprehended for setting fire to the woods is charged with arson. These laws undoubtedly reflect to some extent the prevailing norm of the larger culture. For this study, however, we are not particularly interested in establishing the norm regarding woods burning for the entire state. But it is of interest to note that the dominant norms identified in the area studied support the laws of the state.

Latent Incendiarists Did Not Represent A Subculture.—Having determined those persons who supported deviant norms, it was only necessary to determine if intense interaction existed among them to ascertain whether or not a subculture existed; that is, to determine whether or not they represented a collectivity of persons who shared similar norms and had effective interaction. The amount of interaction was measured by asking the respondents: "Whom do you visit with most?" To this question most respondents listed two or three persons by name. Only one of the nine deviants listed another deviant as a person with whom he visited most. (See Table 7.) That is, of the 16 persons

TABLE 7.—Number and Percent of Latent Incendiarists, Marginals, and Conformists Visted Most by Latent Incendiarists and Conformists

	Latent incendiarists		Marginals		Conformists		Total	
	N	%	N	%	N	%	N	%
Latent incendiarists	(1)	6	(4)	25	(11)	69	(16)*	100
Conformists	(2)	5	(9)	22	(29)	73	(40)**	100

*Five of the persons named lived outside the area studied and the category of such persons could not be determined.

**For the purpose of comparing the latent incendiarists with the conformists, a 25% random sample of conformists was drawn.

living in the area studied whom the latent incendiarists said they visited most, only one was a latent incendiarist. Four persons listed by the latent incendiarists were marginals and the remainder were conformists. Since the latent incendiarists do not appear to interact intensively among themselves, the data would suggest that a deviant subculture supporting woods burning does not exist in the area.

Latent Incendiarists Live Relatively Isolated Lives.—It was predicted that latent incendiarists would be isolates; that is, that they would list fewer persons outside their neighborhood as persons they visited most. To determine where the persons with whom the respondents visited most lived, each respondent was asked to indicate who he visited most and whether these persons lived in the neighborhood, the local community, a contiguous community, elsewhere in the parish, elsewhere in Louisiana, or out of the state. The data collected supported the belief that latent incendiarists, as compared to conformists, are isolates with regard to visiting persons outside their neighborhood.

Of the 21 persons listed as being visited most by the nonconformists, only one person lived outside the immediate neighborhood and this person was the mother of the deviant. On the other hand, over half (56 percent) of the persons visited most by conformists lived beyond the neighborhood boundaries. These findings lead to the conclusion that latent incendiarists are less integrated into the larger community than are conformists.

With regard to the above findings, it cannot be said that the latent incendiarists were less integrated into the local neighborhood. However, it was determined that substantially fewer of the persons visited most by deviants than persons visited most by conformists reciprocated these visits. For example, 19 percent of the persons listed by deviants as persons visited most by them reciprocated with such a statement. By contrast, a check on a 25 percent random sample of conformists indicated twice as many (39 percent) of the persons listed by them as visited most reciprocated by naming these respondents as persons they visited most frequently.

In conclusion, it is obvious that the data collected from household heads in the study does not indicate that a subculture exists which supports incendiary norms. This finding tends to validate the conclusions of previous studies of delinquents, which suggest that rural deviancy is not the result of criminal or deviant subcultures.

Summary

The study reported in this publication was undertaken to determine whether or not the residents in an area of high incendiarism held views which might account for local fire-setting activities. Specifically, the objectives were to: (1) determine whether attitudes and beliefs detrimental to forest conservation were widespread; (2) determine whether antagonistic views were held toward forest service agencies and their employees, and (3) determine whether a distinct "fire" subculture prevailed in the area.

The methods and procedures of the study included the interview of 259 household heads in an area characterized by a high rate of forest fires. These individuals lived on farms ranging from less than 10 to over 200 acres. Most of them had income from sources other than farming and about half owned cattle. Their median age was 53 years and about half of them had completed less than eight grades of education. Almost all of them were Protestant and two-thirds had annual incomes of less than $5,000. They were characterized by low levels of formal social participation and lived rather isolated lives.

Each respondent was asked to react to seven statements directly or indirectly related to forest conservation. Their responses were indicative of their attitudes and may be summarized as follows:

1. Forests were generally recognized as important to the local economy.
2. Trees were generally thought to be a good investment.
3. It was widely believed that trees should be grown on marginal land not useful for other enterprises.
4. Fires were generally believed to help in getting rid of bugs, snakes and other pests.
5. It was rather widely believed that fires improve the looks of the countryside.
6. Most individuals felt fire setting should be regulated by law.
7. Most individuals felt it was wrong to burn another person's land without his permission.

Altogether, it is possible to conclude that a moderate conservation orientation existed in the area.

Residents' attitudes toward Louisiana Forestry Commission personnel were also checked. Responses to questions of this type indicated the following feelings:

1. There were mixed feelings about the contribution of the forestry commission to small farmers.

2. Representatives of the forestry commission were generally thought to be sincere in their efforts.

3. The forestry commission was generally thought to be fair in its local hiring practices.

4. Opinions regarding the integrity of the forestry commission in repairing damage to fences done while fire fighting were mixed.

5. A considerable number of respondents were of the belief that suppressing fires represented the sole work of the forestry commission.

6. A minority of individuals were convinced that forest agency employees seldom did enough to justify their salaries.

7. Most persons thought the forestry commission was doing all it could be expected to do.

When statistically summarized, the above findings indicate a moderately favorable image of forest agencies.

Tests made to determine if a "fire" subculture existed in the study community produced negative results. Only nine persons were classifiable as latent incendiarists. These persons did not interact a great deal among themselves, yet their contacts were almost exclusively local. In other words, they were relative isolates when compared with those holding more "conformist" attitudes.

It appears from these findings that a small number of individuals account for the forest fires in the study area. These individuals consistently held attitudes negative to fire prevention and conservation. At the same time a majority of the residents appear to understand and appreciate the necessity for both fire prevention and conservation. The implications of these findings for forest agencies appear to have two thrusts. On the one hand, the scope of the problems of fire prevention and conservation does not appear to have the magnitude that many have thought. Apparently many persons in woods-burning areas have already internalized views and images conducive to these goals. In the second place, the persons who are potential fire setters appear to be out of contact with sources of information which might change their views. The inauguration of a "contacter" program to bring fire prevention and other messages directly to these individuals, as has been done on an experimental basis, thus appears a wise strategy.

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Response of Rice to Time of Seeding In Louisiana

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Response of Rice to Time of Seeding in Louisiana[1]

NELSON E. JODON AND WILLIAM O. MCILRATH[2]

Introduction

The purpose of this bulletin is to show (1) the approximate expected harvest dates of current rice varieties when seeded at intervals through the usual range of the planting season; and (2) the relationship of seeding date to potential yield per acre, vegetative growth (height), and milling quality (head rice).

In southwest Louisiana, rice (*Oryza sativa,* L.) is germinating, growing, or ripening over a 7- or 8-month crop season. Suitable varieties are available and weather conditions are favorable for the successful seeding of rice from early March to mid-June. However, the production of maximum yields is not assured simply by planting within dates that allow sufficient time for the production of good quality grain.

Rice growers tend to seed early so as to harvest early, hoping to gain by good yields and prompt returns. For a ratoon crop, early seeding is necessary. It also makes way for a soybean crop. Usually, in areas of light soil, a satisfactory seedbed for rice can be prepared in early March. The "water seeding" broadcast method makes early seeding possible on heavier soil also.

Because of early seeding and the popularity of short-season varieties, the major part of the crop is mature in mid-August. More efficient use of drying facilities and more orderly marketing would be possible if the harvest season were not so compressed. Also, local midsummer rainstorms frequently result in lodging and unfavorable conditions for harvesting. Early autumn weather usually is more favorable, and rice maturing at that time often is of better quality. However, late rice apparently yields less.

Date-of-seeding experiments, an essential phase of variety testing, are used to help determine differences in the duration of the growing period. They provide information on timing seeding for maximum production and scheduling of fertilizer and other chemical applications. This makes for orderly harvesting of varieties and fields. Previous results of such

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experiments, including Louisiana data for 1953-1961, are summarized in U.S.D.A. Agricultural Handbook No. 289, "Rice In the United States: Varieties and Production."[3] Results presented here, obtained for 1963-1969 at the Rice Experiment Station, Crowley, Louisiana, pertain to varieties currently in production.

Experimental Procedure

Groups of varieties were seeded at 3- or 4-week intervals each season, beginning as early as possible in March and ending in May or June. From three to seven seedings were made each season. All experiments were conducted with small plots consisting of single or double rows, seeded with a single-row planter. All fertilizer was applied in the row under the seed at recommended rates. Usually, there were three or four replications, but in two years the number of seedings was increased to seven, with only one plot of each seeded each time. Days from seeding to the start of panicle emergence from the boot was used as the most reliable index of the growing period, because date of first heading can be recorded more reliably than date of full maturity. Date of first heading also represents the date of first flowering. Ordinarily, most varieties of rice are fully ripe in about 35 days after first flowering; however, maturation period may vary from 30 to as many as 45 to 50 days, depending chiefly on temperature.

Plant height was measured in inches to the tip of the panicles. Plots were harvested with a sickle. Usually, the differences in maturity dates made it impossible to drain the test areas for harvesting. Bundles were dried in a screen shed and threshed as soon as possible. Weights were converted to average yields in pounds per acre. Milling quality data were based on 125-gram milling samples.

Growing Period Duration in Relation to Date of Seeding

Rice varieties differ greatly in the length of time they require to produce a crop. The rice grower uses his knowledge of this in programming his crop season. Varieties previously grown had life cycle durations of 145 days (Blue Rose) to 165 days (Rexoro). At present, however, the range is from 100 days for Belle Patna, the earliest commercial variety grown, to 135 days for Bluebonnet 50, the latest.

Duration of the life cycle differs between varieties and varies for a given variety in response to growing conditions. The chief factors involved are response to photoperiod, the daily light-dark relationship response, and to temperature. Plant nutrition also has some influence.

Vegetative growth of a photoperiod-sensitive variety continues until day length has decreased to the critical number of hours required to initiate the reproductive stage. Influenced by its specific photoperiod, such a variety forms a panicle-bud at its growing point. Development is rapid, and usually the panicle begins to emerge from the boot within a month. Thus, whenever seeded, a photoperiod-sensitive variety tends strongly to head at the same date. Such varieties are long-season and late maturing. Most fail to head early enough to mature in Louisiana, and those that do mature have a longer growing period than is desired by rice growers.

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[3] Varietal response to seeding date, pages 51-56.

Photoperiod-nonsensitive varieties are able to flower during the long days of summer. They develop vegetatively for a relatively fixed period, then go into the reproductive stage. No sharp response to a particular photoperiod is needed to initiate the change. Most photoperiod-nonsensitive varieties mature early or in midseason while the days are relatively long. However, some photoperiod-nonsensitive varieties, such as Rexoro, mature late in Louisiana.

Only photoperiod-nonsensitive varieties are currently grown in Louisiana, because they mature in the shortest time. No photoperiod-sensitive varieties have been grown in Louisiana in the past 25 years.

Figure 1[4] illustrates the difference between the two types. The life-cycle duration of photoperiod-nonsensitive varieties is fairly constant, except as extended by cool or reduced by warm temperatures. In warm weather, a field seeded 10 days later than another matures about 10 days later.

On the other hand, a photoperiod-sensitive variety tends to mature at about the same date regardless of the time of seeding. As shown in Figure

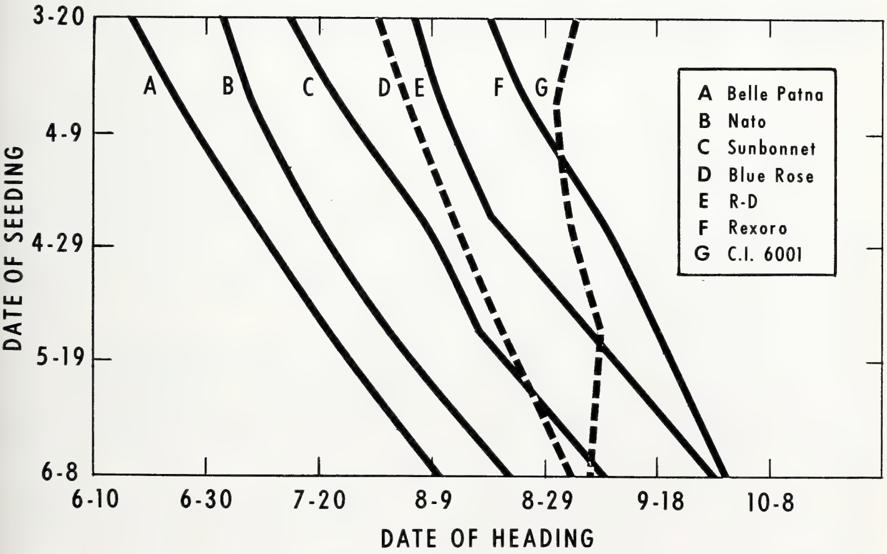

FIG. 1—Time of heading of photoperiod-sensitive and -nonsensitive rice varieties in relation to seeding date.

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[4] Reproduced from U. S. D. A. Agricultural Handbook No. 289, "Rice in the United States: Varieties and Production."

1, Sunbonnet matures earlier than Blue Rose from early and medium seeding dates. From late seedings, however, Blue Rose matures before Sunbonnet because of its day-length response. C. I. 6001 shows a stronger response than Blue Rose and heads early in September from all seedings. It matures later than the other varieties when seeded very early, but earlier than Rexoro from medium dates of seeding and as early as Sunbonnet from early June seedings.

For convenience, current varieties are classified on the basis of growing period duration as very early, early, midseason, and late. The varieties in these groups in a date-of-seeding experiment conducted 1963-1965 are listed in Table 1.[5]

TABLE 1.—Rice varieties included in a date-of-seeding experiment, 1963-1965

Maturity groups[1]			
Very early (100-115 days)	Early (116-130 days)	Midseason (131-145 days)	Late (146-170 days)
Belle Patna	Gulfrose	Toro	RD
C.I. 9489	Nato	Sunbonnet	Texas Patna
C.I. 9553	Saturn	Arkrose	Rexoro selection
C.I. 9543	C.I. 9594	C.I. 9551	Rexoro
	Lacrosse	Blue Rose	
	Dawn		
	P.I. 215936		

[1]Based on indicated approximate ranges of growing period durations.

Results of the experiment (Table 2) show that the average period in days from seeding to first heading, for each of the variety groups, became progressively shorter from each successive seeding date. The average growing period from the second seeding ranged from 9 to 11 days shorter than from the first, depending on the group. Since the interval between seedings was 23 days, this is an average reduction of about one day for every two-day delay in seeding.

The average reduction of growing period from seeding at the third date as compared with the second was less regular and not so great. It was very small in the early group, but amounted to about one day for four days' delay in seeding in the very early, one day for three in the midseason, and two days for five in the late group.

Average growing period reduction from seeding at the fourth date as compared with the third ranged from one day for four to two days for five days' delay.

The interval between the first and fourth dates averaged 73 days, and the reduction of the average growing period overall was 22 days for the

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[5]Varieties in 1966-1969 experiments are not listed because numerous experimental lines were included and many changes were made each season.

TABLE 2.—Growing-period duration within maturity groups in relation to time of seeding in an experiment conducted 1963-1965

Variety groups and average seeding date	Number		Average days — seeding to first heading				Interval between seedings (days)	Growing period reduced (days)	Ratio[1]
	Days seeding to heading	Varieties per group	1963	1964	1965	Avg.			
Very early	70-73	4					(differences)		
March 28			88	82	75	82			
April 20			73	73	72	73	23	9	0.39
May 12			67	68	67	67	22	6	0.27
June 9			61	59	60	60	28	7	0.25
Average			72	71	69	70	73	21	0.29
Early and medium early	82-89	7							
March 28			103	97	90	97			
April 20			88	84	86	86	23	11	0.48
May 12			85	82	84	84	22	2	0.09
June 9			75	74	75	75	28	9	0.32
Average			88	84	84	86	73	22	0.30
Midseason	98-105	5							
March 28			121	113	110	115			
April 20			106	104	103	104	23	11	0.48
May 12			98	94	99	97	22	7	0.32
June 9			85	86	88	86	28	11	0.39
Average			103	99	100	101	73	21	0.29
Late	119-130	4							
March 28			146	139	134	140			
April 20			129	127	130	129	23	11	0.48
May 12			119	121	120	120	22	9	0.41
June 9			106	109	114	110	28	10	0.36
Average			125	124	125	125	73	21	0.29

[1] Days growing period is shortened divided by interval between seedings.

early group and 21 for the others. In other words, rice seeded in early June matured in about 3 weeks less time than that seeded 10 weeks earlier.

The shorter growing periods resulting from later seedings are attributed mainly to more rapid plant development because of increasingly higher temperatures through the planting season. Probably, the interval from seeding to heading obtained from the last seeding approximates the average minimum for the respective groups under Louisiana conditions. Under tropical conditions, where temperatures remain constantly high, the growing period may be even shorter for photoperiod-nonsensitive varieties.

The effect of the warming trend during the planting season on the growing period of Saturn, a typical photoperiod-nonsensitive variety, is illustrated in Figure 2. Plant development is hastened by increasing temperatures, and the intervals between harvest dates are shorter at first than the intervals between seeding dates. Apparently, some time in May, the duration of the life cycle approaches the minimum for the variety; the interval between harvest dates then becomes the same as that between seeding dates. If, however, seeding is delayed to very late dates, the interval between ripening dates may be greater than between seeding dates, because of retardation of ripening by low temperatures, as indicated by dash lines in Figure 2.

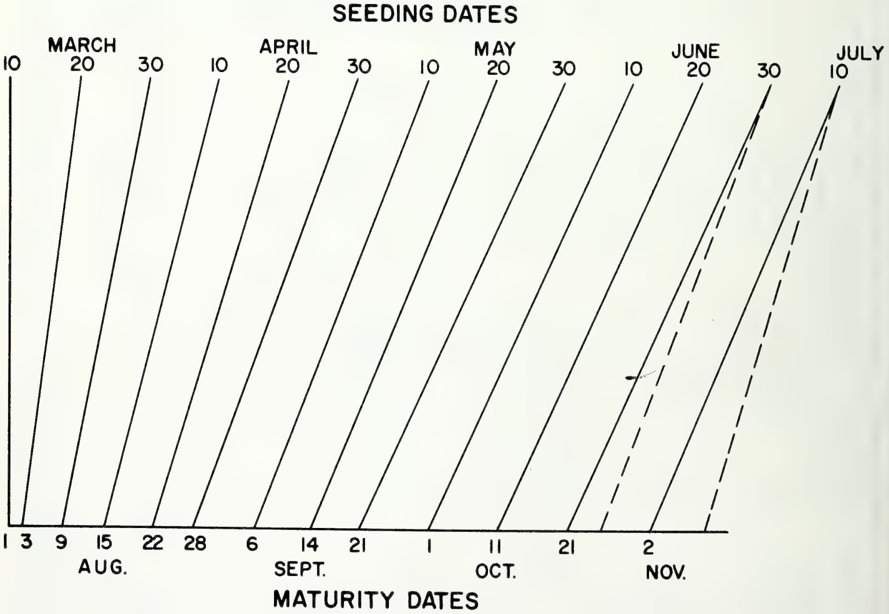

FIG. 2—Relation of harvest date to time of seeding of Saturn, a typical photoperiod-nonsensitive rice variety.

The average periods in days from seeding to first heading and to full maturity of grain for current varieties are shown in Table 3. The averages were obtained from a considerable number of variety trials conducted during the 7-year period 1963-1969. Since the tests were seeded at irregular intervals throughout the planting season, the average growing periods shown in the table indicate the average differences in growing periods of the current varieties. The average durations coincide approximately with the actual period resulting from April 15 seedings of the varieties, which date is about the midpoint of the rice planting season in Louisiana.

The interval from the time the tips of the panicles begin to emerge from the boot (first flowering) until the grain reaches maturity, approximately 35 to 40 days, is much the same for all Louisiana varieties. Environmental differences, however, may shorten or prolong the maturation period. In hot weather, maturation may require only 30 days, while in cool weather it may require 35 to 50 days. High rates of fertilization with nitrogen and lodging also delay the ripening process.

TABLE 3.—Average duration in days of periods from seeding to first heading and full maturity of current rice varieties

	Number tests averaged	Average days To heading[1]	To maturity[1]	Heading to maturity (difference)
Belle Patna	47	70	108	38
Bluebelle	45	76	117	41
Saturn	63	84	126	42
Nato	60	86	127	41
Dawn	51	88	129	40
Starbonnet	38	96	136	39
Bluebonnet 50	42	104	141	37
C.I. 9551	49	105	142	37

[1] Periods approximately the same as from seeding at the median seeding date in southwest Louisiana—April 15.

Information on the length of growing period of available varieties in relation to time of seeding is useful to rice growers as an aid in planning seasonal operations. Accumulated data from the many variety tests conducted 1963 through 1969 provide a basis for the prediction of approximate heading and harvest dates, and thus for timing the sequence of seeding varieties or fields for orderly consecutive harvesting. Schedules for seven current varieties and one experimental variety are presented in Table 4. The table shows, for 5-day seeding intervals, the expected average period in days, and the corresponding dates, from seeding to first heading and to full maturity of grain, for each variety. The schedules are based on dates of first heading because these are more readily observed than dates of maturity. Actual heading dates resulting from seedings within 5-day intervals were averaged, and the averages adjusted from date to date. The predicted date of full maturity for each variety was determined by adding to the date of first heading the average number of days of the maturation period, heading to maturity. The varieties included in Table 4 and the respective number of days added were: Belle Patna (36), Bluebelle (39), Saturn (40), Nato (39), Dawn (38), Starbonnet (37), Bluebonnet (36), and C.I.9551 (36).[6]

Fields seeded earlier than March 5, the first date tabulated, are not

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[6] Maturation periods shown in Table 2 were reduced somewhat for the purpose of Table 4 because harvest probably begins sooner in farm practice than in experimental plots.

TABLE 4.—Approximate growing periods of eight rice varieties from seedings at 5-day intervals. Based on experiments conducted 1963-1969

Belle Patna

Seeding date		Days to first heading	Date of first heading	Days to maturity	Date mature
March	5	96	6-9	132	7-15
	10	94	6-12	130	7-18
	15	90	6-13	126	7-19
	20	87	6-15	123	7-21
	25	84	6-17	120	7-23
	30	80	6-18	116	7-24
April	5	76	6-20	112	7-26
	10	74	6-23	110	7-29
	15	72	6-26	108	8-1
	20	72	7-1	108	8-6
	25	69	7-3	105	8-8
	30	69	7-8	105	8-13
May	5	67	7-11	103	8-16
	10	66	7-15	102	8-20
	15	65	7-19	101	8-24
	20	64	7-23	100	8-28
	25	64	7-28	100	9-2
	30	64	8-2	100	9-7
June	5	63	8-7	99	9-12
	10	60	8-9	96	9-14
	15	60	8-14	96	9-19
	20	60	8-19	96	9-24
	25	60	8-24	96	9-29
	30	60	8-29	96	10-4
July	5	60	9-3	96	10-9
	10	61	9-9	98	10-16
	15	62	9-15	100	10-23

(continued)

likely to mature appreciably earlier, because temperatures usually are too low for germination or growth so early in the season. Crops seeded so late as to mature late in October or in November may be delayed in maturity, or even damaged by cold weather or frost (Figure 2).

Growers may find additional uses for these schedules (Table 4). Knowing when to expect a field to be ready for harvest enables the grower to have his equipment ready in time. Also, the schedules may prove helpful in timing the application of recommended fertilizer top-dressings, insecticides, and herbicides.

TABLE 4 *(continued)*
Bluebelle

Seeding date	Days to first heading	Date of first heading	Days to maturity	Date mature
March 5	106	6-19	145	7-28
10	100	6-18	139	7-27
15	95	6-18	134	7-27
20	90	6-18	129	7-27
25	85	6-18	124	7-27
30	80	6-18	119	7-27
April 5	78	6-24	118	7-31
10	77	6-26	117	8-5
15	76	6-30	117	8-8
20	74	7-3	113	8-11
25	74	7-8	113	8-16
30	72	7-11	111	8-19
May 5	70	7-14	109	8-22
10	70	7-19	109	8-27
15	70	7-24	109	9-1
20	70	7-29	109	9-6
25	70	8-3	109	9-11
30	70	8-8	109	9-16
June 5	70	8-14	109	9-22
10	70	8-19	109	9-27
15	70	8-24	111	10-4
20	74	9-2	113	10-11
25	75	9-8	114	10-17
30	75	9-13	114	10-22
July 5	75	9-18	114	10-27
10	75	9-23	114	11-1
15	75	9-28	114	11-6

(continued)

TABLE 4 *(continued)*

Saturn

Seeding date		Days to first heading	Date of first heading	Days to maturity	Date mature
March	5	109	6-22	149	8-1
	10	104	6-22	144	8-1
	15	99	6-22	139	8-1
	20	96	6-24	136	8-3
	25	94	6-27	134	8-6
	30	92	6-30	132	8-9
April	5	88	7-2	128	8-11
	10	87	7-6	127	8-15
	15	86	7-10	126	8-19
	20	84	7-13	124	8-22
	25	81	7-15	121	8-24
	30	80	7-19	120	8-28
May	5	79	7-23	119	9-1
	10	79	7-28	119	9-6
	15	79	8-2	119	9-11
	20	77	8-5	117	9-14
	25	76	8-9	116	9-18
	30	74	8-12	114	9-21
June	5	74	8-18	114	9-27
	10	73	8-22	113	10-1
	15	73	8-27	113	10-6
	20	73	9-1	113	10-11
	25	73	9-6	113	10-16
	30	73	9-11	113	10-21
July	5	73	9-16	113	10-26
	10	73	9-21	115	11-2
	15	74	9-27	115	11-7

(continued)

TABLE 4 *(continued)*

Nato

Seeding date		Days to first heading	Date of first heading	Days to maturity	Date mature
March	5	112	6-25	151	8-3
	10	109	6-27	148	8-5
	15	105	6-28	144	8-6
	20	101	6-29	140	8-7
	25	97	6-30	136	8-8
	30	94	7-2	133	8-10
April	5	92	7-6	131	8-14
	10	90	7-9	129	8-17
	15	88	7-12	127	8-20
	20	86	7-15	125	8-23
	25	84	7-18	123	8-26
	30	79	7-18	118	8-26
May	5	76	7-20	115	8-28
	10	76	7-25	115	9-2
	15	76	7-30	115	9-7
	20	76	8-4	115	9-12
	25	76	8-9	115	9-17
	30	76	8-14	115	9-22
June	5	76	8-20	115	9-28
	10	76	8-25	115	10-3
	15	76	8-30	115	10-8
	20	76	9-4	115	10-13
	25	76	9-9	115	10-18
	30	76	9-14	115	10-23
July	5	76	9-19	115	10-28
	10	77	9-25	116	11-3
	15	77	9-30	116	11-8

(continued)

TABLE 4 *(continued)*
Dawn

Seeding date		Days to first heading	Date of first heading	Days to maturity	Date mature
March	5	110	6-23	148	7-31
	10	105	6-23	143	7-31
	15	101	6-24	139	8-1
	20	97	6-25	135	8-2
	25	96	6-29	134	8-6
	30	95	7-3	133	8-10
April	5	92	7-6	130	8-13
	10	91	7-10	129	8-17
	15	91	7-15	129	8-22
	20	90	7-19	128	8-26
	25	88	7-22	126	8-29
	30	86	7-25	124	9-1
May	5	85	7-29	123	9-5
	10	83	8-1	121	9-8
	15	83	8-6	121	9-13
	20	82	8-10	120	9-17
	25	80	8-13	118	9-20
	30	79	8-17	117	9-24
June	5	79	8-23	117	9-30
	10	80	8-29	118	10-6
	15	80	9-3	118	10-11
	20	82	9-10	120	10-18
	25	82	9-15	120	10-23
	30	84	9-22	122	10-30

(continued)

TABLE 4 *(continued)*
Starbonnet

Seeding date		Days to first heading	Date of first heading	Days to maturity	Date mature
March	5	120	7-3	157	8-9
	10	115	7-3	152	8-9
	15	113	7-6	150	8-12
	20	108	7-6	145	8-12
	25	105	7-8	142	8-14
	30	101	7-9	138	8-15
April	5	100	7-14	137	8-21
	10	100	7-19	137	8-25
	15	100	7-24	136	8-29
	20	98	7-27	135	9-2
	25	95	7-29	132	9-4
	30	94	8-2	131	9-8
May	5	93	8-6	130	9-12
	10	92	8-10	129	9-16
	15	90	8-13	127	9-19
	20	90	8-18	127	9-24
	25	87	8-20	124	9-26
	30	86	8-24	123	9-30
June	5	85	8-29	122	10-5
	10	86	9-4	123	10-11
	15	86	9-9	123	10-16
	20	87	9-15	124	10-22
	25	88	9-21	125	10-28
	30	88	9-26	125	11-2

(continued)

TABLE 4 *(continued)*
Bluebonnet 50

Seeding date	Days to first heading	Date of first heading	Days to maturity	Date mature
March 5	124	7-7	160	8-12
10	122	7-10	158	8-15
15	118	7-11	154	8-16
20	114	7-12	150	8-17
25	113	7-16	149	8-21
30	110	7-18	146	8-23
April 5	106	7-20	142	8-25
10	106	7-25	142	8-30
15	104	7-28	141	9-3
20	102	7-31	138	9-5
25	100	8-3	136	9-8
30	99	8-7	135	9-12
May 5	98	8-11	134	9-16
10	98	8-16	134	9-21
15	98	8-21	134	9-26
20	97	8-25	133	9-30
25	95	8-28	131	10-3
30	95	9-2	131	10-8
June 5	95	9-8	131	10-14
10	95	9-13	131	10-19
15	95	9-18	131	10-24
20	96	9-24	132	10-30
25	97	9-30	133	11-5

(continued)

TABLE 4 *(continued)*
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Seeding date		Days to first heading	Date of first heading	Days to maturity	Date mature
March	5	128	7-11	164	8-16
	10	125	7-13	161	8-18
	15	122	7-15	158	8-20
	20	120	7-18	156	8-23
	25	116	7-19	152	8-24
	30	113	7-21	149	8-26
April	5	111	7-25	147	8-30
	10	109	7-28	145	9-2
	15	106	7-30	142	9-4
	20	105	8-3	141	9-8
	25	104	8-7	140	9-12
	30	102	8-10	138	9-15
May	5	101	8-14	137	9-19
	10	98	8-16	134	9-21
	15	98	8-21	134	9-26
	20	98	8-26	134	10-1
	25	98	8-31	134	10-6
	30	98	9-5	134	10-11
June	5	98	9-11	134	10-17
	10	96	9-14	132	10-20
	15	96	9-19	132	10-25
	20	96	9-24	132	10-30
	25	97	9-30	133	11-5

Yield in Relation to Date of Seeding

Louisiana growers are inclined to seed their rice crops very early. The method of broadcast seeding in standing water has made early seeding possible where otherwise it would be necessary to wait indefinitely for suitable field moisture conditions for drill seeding. Farmers' experience is that higher yields often are obtained by seeding at the earliest opportunity rather than by waiting for warmer, more favorable growing weather.

Date-of-seeding experiments conducted over the past 7 years provide information on the productivity of standard and experimental varieties from seedings at intervals through the planting season. Twenty varieties were included in an experiment carried through the 3-year period 1963-1965. Varieties adapted to southwest Louisiana conditions, ranging from the earliest to the latest, were included (Table 1). The results, summarized by groups based on the length of the growing season, are presented in Table 5.[7] The relative merits and comparative yields of the individual varieties are not discussed here.

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[7] Analysis of variance of the complete data showed highly significant differences between years, dates of seeding, and varieties, and also highly significant interactions of dates and years, varieties and years, and varieties and dates.

TABLE 5.—Average yields in pounds per acre of 20 rice varieties divided into four maturity groups and seeded at intervals on four dates in each of three seasons, 1963-1965

Variety groups and average seeding dates	Number		Average pounds per acre					
	Days seeding to heading	Varieties per group	1963	1964	1965	By dates in groups	By dates in first 3 groups	By dates in all groups
Very early	70-73	4						
March 28			4087	4728	4612	4476		
April 20			4429	5071	3706	4402		
May 12			4315	3594	3456	3788		
June 9			3864	3185	2735	3261		
Average			4174	4145	3627	3982		
Early and medium early	82-89	7						
March 28			4906	5080	5401	5129		
April 20			4921	4939	3901	4587		
May 12			4792	4178	3721	4230		
June 9			4339	3148	2268	3252		
Average			4740	4336	3823	4300		
Midseason	98-105	5						
March 28			4372	3847	3863	4027	4544	
April 20			4895	4616	3315	4275	4421	
May 12			4428	3100	3010	3513	3844	
June 9			3604	2906	2178	2896	3136	
Average			4325	3617	3092	3678	3986	
Late	119-130	4						
March 28			3169	2434	2822	2808		4110
April 20			3954	2923	2009	2962		4057
May 12			2318	2132	2570	2340		3468
June 9			2947	616	1992	1852		2815
Average			3097	2026	2348	2490		3613
Annual average			4084	3531	3223			

Plots were single rows spaced 15 inches apart. Since the varieties probably were unable to take advantage of all the available area, the calculated yields were low in comparison with those obtained from closer spacings. Early medium-grain varieties produced the highest average yields, and the late maturing varieties the lowest. The very early group was second and the midseason group third. The average annual yield for 1963 was higher than that of 1964 or 1965.

The highest average yield for a seeding date was obtained from the March 28 seeding. However, the average for the second date, April 20, was nearly as high. Seedings with an average date of May 12 showed a decline in productivity, and June 12 seedings showed a marked reduction. This pattern was consistent within all four groups of varieties, except that for the second seeding of the early and medium early varieties, the yield dropped off more abruptly. Thus, the results indicate that better yields may be expected from seedings before the end of April than from May and June seedings.

The 1966 and 1967 experiments included groups of 17 to 23 entries each in the very early long- and medium-grain, early medium-grain, and midseason long-grain variety groups (Table 6).[8] The higher yields obtained in 1967 were attributed to the use of double rows, whereas in 1966 single-row plots were still in use. Seeding dates ranged from March 8 to June 22, a wider distribution than in the 1963-65 experiments. The number of seedings was increased to seven, with dates replacing replications; that is, only single plots of the varieties in each group were seeded on each date. Since successive seeding dates fell fairly near the same day of the month in both 1966 and 1967, the results were averaged. The highest yield was obtained from the earliest seeding, which was more than two weeks earlier than in the 3-year experiment. However, there was no sharp decline until late May, when yields fell off markedly. Thus, the results from these two seasons indicate that early-May seedings may yield as well as most April seedings.

In 1968 and 1969, the very early group was not included in date-of-seeding tests because such varieties comprised only a minor part of the Louisiana rice crop. Twenty-three varieties each were entered in the early medium-grain and the early to midseason long-grain groups in 1968 and 20 in 1969. The seeding dates were restricted to three each year, but three replications were used for each seeding (Table 7).

The averages of the two groups for the total of six seedings in the two years again show high yields for very early seedings. The lower yield for the late-April seeding in 1969 seemed to result from less favorable soil and seedbed conditions. Management of the tests in 1969 was changed to include treatment with a systemic insecticide to control root maggots. Possibly, this contributed to the higher than usual yields from the late-May seeding. It suggests that, with improved plant protective practices,

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[8] Late maturing varieties were no longer in production. They were tested in 1966 but not thereafter; therefore results were omitted from Table 6.

TABLE 6.—Average yields in pounds per acre of three groups of 20 varieties each seeded at intervals on seven dates in each of two seasons, 1966-1967

Group	Year	Seeding dates and average pounds per acre																Avg.
		Mar		Mar		Apr		Apr		May		May		May		June		
Very early	1966	10	3999	25	3284	7	3448	–	–	3	3449	17	3760	31	2608	22	1910	3265
	1967	8	3588	23	3780	7	4308	25	4584	–	–	11	3858	25	3342	16	3474	4026
Early medium-grain	1966	10	3609	25	4191	7	2464	–	–	3	3579	17	2868	31	2834	22	1867	3002
	1967	8	4619	23	3512	7	4425	25	5349	–	–	11	4684	25	3695	16	2759	4146
Early and midseason long-grain	1966	10	4989	25	3196	7	3864	–	–	3	2528	17	3835	31	3065	22	1972	3350
	1967	8	5166	23	4608	7	4362	25	4572	–	–	11	4170	25	3348	16	3240	4212
Average			4328		3762		3812						3863		3082		2504	3628
									4010									

TABLE 7.—Average yields in pounds per acre of two groups of rice varieties seeded at intervals on three dates in each of two seasons, 1968-1969

	Seeding dates and average pounds per acre					
Group	March 8 1968	March 27 1969	April 17 1968	April 23 1969	May 6 1968	May 24 1969
Early	5732	5267	4827	4304	3945	4360
Midseason	6192	4256	4894	4066	4829	4739
Average	5962	4762	4861	4185	4387	4550

the period during which rice can be planted with reasonable expectation of a profitable yield may be extended.

Results from the date-of-seeding experiments, together with those from numerous other variety tests, were used to develop a curve showing the trend, through the season, of average yields in relation to time of seeding (Figure 3). The curve was calculated from the average yields of 145 tests conducted during the 7-year period 1963-1969. Results from tests of long-season varieties were excluded to make the data more representative of the types of varieties currently in production.

The curve indicates that, although earliest seedings result in high

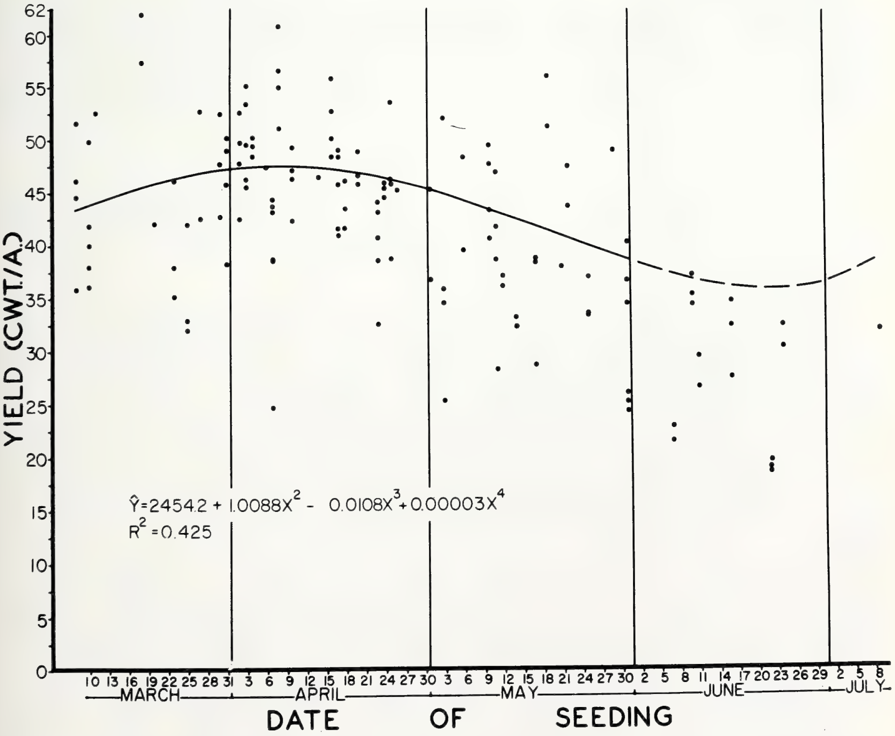

FIG. 3—Average yields of rice variety test groups in relation to date of seeding.

yields, maximum production is obtained from early-April seedings. A slight decline during the latter part of April and early May is indicated. After the first few days of May, however, the curve indicates that prospects for high yields drop off quite sharply.

Numerous factors probably contribute to the low level of productivity resulting from late seedings, including: (1) shorter growing season, because growth is more rapid in warm weather; (2) shorter days, reducing the amount of solar energy received; (3) more cloudy weather, also reducing solar energy; (4) more rapid depletion of available nitrogen because of prevailing higher temperatures; and (5) heavier losses from insects and diseases which earlier seedings escape to some degree.

Plant Height, Yield, and Time of Seeding

Plant height of a given rice variety is influenced by fertilizer rate and timing, and higher yields are often associated with taller stalks.[9] However, an adverse effect on yield results where plant height contributes to lodging. Plants in crowded stands are shorter and weaker than in thin stands. Possibly, if the weather is cloudy during the internode elongation stage, the plants may grow taller because of the reduced light. The only reported relationship between height and time of planting is shorter stature from later seedings.

The varieties included in the 1963-1965 experiment usually were shortest when seeded in June (Table 8). Exceptions occurred in 1965; the early varieties averaged taller from the June than from the April seedings, and the midseason varieties averaged taller from the June than from the May seedings. But yields (Table 5) were lower from June seedings in each year and in all groups of varieties.

The 1966 June seeding produced the lowest yields (Table 6) and usually the shortest plants (Table 9). Plants were taller from the 1967 mid-June than from the late-May seeding, but the yield of only one of the three test groups was higher.

In 1968, one group yielded less from the early-May than from the mid-April seeding (Table 7), but plant heights were less in both test groups (Table 9). Both heights and yields were lower from the 1969 mid-April seeding of the long-grain group than from the earlier and later seedings. Yields from the April and May seedings of the medium-grain group were nearly equal, but the June seeding averaged 5 inches taller.

Generally, very late seeding resulted in shorter stature along with lower yields, but reduction in height was less consistent than reduction in yield.

However, the earlier seedings did not always produce the tallest plants. Plant height tended to be greater in tests seeded in the period during which production began to show a decline. In the 1963-1965 experiments, plant heights in the third seeding were generally as great as

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[9] Positive but low correlations between yield and height were obtained from nearly all tests.

TABLE 8.—Average heights in inches of 20 rice varieties divided into four maturity groups and seeded at intervals on four dates in each of three seasons, 1963-1965

Variety groups and average seeding dates	Number		Average height (inches)					
	Days seeding to heading	Varieties per group	1963	1964	1965	By dates and groups	By dates in first three groups	By dates in all groups
Very early	70–73	4						
March 28			44.0	51.8	38.2	44.7		
April 20			41.5	48.4	40.0	43.3		
May 12			44.8	48.8	41.9	45.2		
June 9			42.5	45.0	40.1	42.5		
Average			43.2	48.5	40.1	43.9		
Early to medium early	82–89	7						
March 28			43.8	52.1	43.8	46.6		
April 20			42.5	48.5	40.1	43.7		
May 12			46.2	50.0	43.4	46.5		
June 9			43.5	48.1	41.3	44.3		
Average			44.0	49.7	42.2	45.3		
Midseason	98–105	5						
March 28			50.2	55.0	50.3	51.8	47.7	
April 20			48.8	52.6	47.2	49.5	45.5	
May 12			49.6	55.5	40.7	48.6	46.8	
June 9			49.2	51.3	43.7	48.1	44.7	
Average			49.5	53.6	45.5	49.5	46.2	
Late	119-130	4						
March 28			48.1	50.4	50.1	49.5		48.2
April 20			47.2	53.0	48.4	49.5		46.5
May 12			50.5	50.2	47.6	49.4		47.4
June 9			45.0	45.0	43.5	44.5		44.9
Average			47.7	49.7	47.4	48.2		46.7
Annual average			46.1	50.3	43.8			

or greater than those from earlier seedings. The same trend is apparent in the data from the subsequent seasons. Probably, in response to the warmer weather in early May, the primary tiller develops more rapidly and with greater elongation, at the expense of secondary tillers. Thereafter, adverse factors, including reduced day length, cloudy weather, shortened growing period, increased incidence of pests and diseases, and greater loss of nitrogen in hot weather, tend to reduce height along with productivity.

Consequently, it seems unlikely that the rice grower can influence plant height to advantage by adjustment of planting date, except possibly to a slight degree by seeding before the weather warms.

TABLE 9.—Average heights of test groups from date-of-seeding tests, 1966-1969

Variety groups	Average height (inches)							
					1966			
	3-10	3-25	4-7	5-3	5-17	5-31	6-22	Average
Very early maturing	40	37	39	36	44	40	36	39
Early medium-grain	39	40	38	41	46	43	41	41
Early to midseason long-grain	44	40	41	37	42	42	36	40
Average	41	39	39	38	44	42	38	40
					1967			
	3-8	3-23	4-7	4-25	5-11	5-25	6-16	
Very early maturing	35	35	35	43	41	37	40	
Early medium-grain	38	37	42	45	42	39	44	
Early and midseason long-grain	41	41	40	44	41	39	42	
Average	38	38	39	44	41	38	42	
					1968			
	3-18	4-17	5-6					
Early medium-grain	49	48	44					
Early and midseason long-grain	47	45	44					
					1969			
	3-27	4-23	5-22					
Early medium-grain	39	35	40					
Early and midseason long-grain	38	37	40					

Quality in Relation to Time of Seeding

Since hardness of grain is determined largely by environmental conditions prevailing during the ripening period, date of seeding influences milling quality only indirectly. Rice that matures rapidly in hot weather tends to be chalky, while rice that matures slowly in cool weather is more translucent and resistant to breakage. However, temperatures low enough to be injurious while the grain is filling also result in chalky kernels. The highest yielding fields may not produce the best quality rice because, with high levels of fertility, the grain matures less uniformly or is affected by lodging.

Highest average milling, in terms of head rice, for the late maturing

TABLE 10.—Average percent head rice outturn of 20 rice varieties in four maturity groups seeded on four dates in each of three seasons, 1963-1965

Variety groups and average seeding dates	Number		Average percent head rice					
	Days seeding to heading	Varieties per group	1963	1964	1965	By date and groups	By dates in first three groups	By dates in all groups
Very early	70–73	4						
March 28			60	60	56	59		
April 20			57	64	62	61		
May 12			59	57	61	59		
June 9			58	57	58	58		
Average			59	60	59	59.1		
Early and medium early	82–89	7						
March 28			65	65	65	65		
April 20			64	65	66	65		
May 12			65	60	65	63		
June 9			64	64	64	64		
Average			65	64	65	64.3		
Midseason	98–105	5						
March 28			64	55	63	61	61.4	
April 20			60	62	63	62	62.6	
May 12			64	50	57	57	59.8	
June 9			63	57	61	60	60.3	
Average			63	56	61	59.9		
Late	119–130	4						
March 28			51	44	52	49		58.3
April 20			59	53	53	55		60.7
May 12			61	48	57	55		58.7
June 9			66	55	67	63		61.2
Average			59	50	57	55.5		
Average by years			61.3	57.3	60.6			
Grand average								59.7

varieties and on the average for all groups in the 1963-1965 experiment was obtained from the latest seeding (Table 10). But for the other groups, the second date gave highest mill yields. The third date average was lowest because the averages within groups reflected the lower than usual milling of the 1964 third date of seeding. That year, most of the varieties with low milling were maturing in the latter part of August and up to mid-September; it was recorded that "showery conditions prevailed from late June into early September, increasing lodging and favoring blast." Seven seedings ranging from March 10 to June 22 were made of three groups in 1966 (Table 11). Milling tended to be low for the third date (April 7), especially in the very early and midseason groups. The latter was also low milling from the last seeding. On the other hand, milling of early varieties was highest from the latest seeding. Again, it appeared low milling accompanied rainy weather at the time of ripening.

TABLE 11.—Average percent head rice outturn of rice variety groups seeded on seven dates in 1966 and on three dates in 1967, 1968, and 1969

Variety groups	Number entries	——— Average percent head rice ———						
					1966			
		3-10	3-25	4-7	5-3	5-17	5-31	6-22
Very early (long and medium)	16	64	65	61	64	65	65	65
Early (medium)	17	65	64	63	67	66	65	68
Medium early to midseason (long)	23	59	56	55	58	61	61	52
Average		63	62	60	63	64	64	62
					1967			
		3-8	4-7	5-11				
Very early (long and medium)	20	63	61	64				
Early (medium)	20	69	70	69				
Early to midseason (long)	20	65	62	67				
Average		66	64	67				
					1968			
		3-18	4-17	5-6				
Early (medium)	23	63	65	56				
Early to midseason (long)	23	62	55	51				
Average		63	60	54				
					1969			
		3-27	4 23	5-24				
Early (medium)	19	62	66	57				
Early to midseason (long)	19	54	55	53				
Average		58	61	55				

Milling quality was determined on only three of the seven seedings made in 1967. As in 1966, the early-April seeding gave the lowest average milling from the very early and midseason groups. The early group, on the other hand, gave a slightly higher milling average from the April than from the March and May seedings.

In 1968, because of lodging, the latest seeding (May 6) gave low milling quality in both the medium-grain and the long-grain test groups. In 1969, the milling quality of the medium-grain varieties sown late (May 24) was low because of lodging.

Milling quality of rice seeded at any date may be reduced seriously by adverse conditions while the grain is forming and ripening. Generally, rice that ripens in late September or early October is likely to mill better than rice that ripens in July and August. The mid-summer harvest period in southwest Louisiana is a time of frequent heavy local showers, rainy periods, and sometimes high temperatures. Although the highest quality usually is obtained from later maturing crops, ripening conditions late in the season are not always favorable. The possibility of obtaining better quality by late seeding or by growing long-season varieties does not outweigh the advantages of early seeding and early varieties.

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Health Service Planning Regions For Louisiana

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IN COOPERATION WITH
LOUISIANA REGIONAL MEDICAL PROGRAM
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Foreword

This monograph represents the second of three publications being developed by Dr. Alvin L. Bertrand, Dr. Carl F. Baty, Mrs. Virginia P. Steelman, and Mr. Evans W. Curry as part of a project related to the "Delineation of Health Care Regions Within the State of Louisiana." This study was funded through the Louisiana Regional Medical Program as part of its thrust to aid health planning at subregional and community levels.

The distribution of health care resources throughout the state has many implications in planning for the delivery of health services. The first monograph entitled, "The Availability and Distribution of Health Personnel in Louisiana," increased the data base for health planning. Additional variables that influence health care capability are evaluated in this monograph. A formula was developed to delineate medical service regions in the state around nodal urban centers of medical influence. This strategy also revealed certain gray areas in the state where such influence was not clear-cut.

The planning staff of the Louisiana Regional Medical Program has reviewed this monograph. We trust its findings will aid those individuals and agencies doing grassroots health care planning to coordinate their activities and health care resources to greater advantage.

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Director, Louisiana Regional
Medical Program

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Health Service Planning Regions For Louisiana*

CARL F. BATY, ALVIN L. BERTRAND, VIRGINIA P. STEELMAN AND EVANS W. CURRY**

Introduction

The populace of a state or nation has an implicit right to expect the optimum health care that can be delivered by its health agencies and personnel. However, this goal can only be achieved through enlightened planning, which in turn depends upon the availability of basic information. The research reported here represents an attempt to enlarge the scope of information available to health planners in Louisiana and the United States. The inspiration for the research came from a growing appreciation of the vital role which meaningful administrative districts or subregions play in service and planning.

Agencies such as the Louisiana Regional Medical Program, the Louisiana Interdepartmental Health Policy Commission, the Louisiana State Department of Hospitals, and the Louisiana Heart Association operate on a statewide basis. All of these agencies, and many others, function administratively in terms of regional subdivisions of the state. Yet, the individual regionalizations used are not based on a wide range of health and medical care information and in no case are they identical. Such arbitrariness and diversity obviously make the coordination of effort difficult—if not impossible—and reduce the efficiency of health care delivery in the state.

The regional idea is not new in health and medical care circles. Hospital service regions were inaugurated in the U. S. in 1931, and the idea has been widely used since that time. The President's Commission on the Health Needs of the Nation, appointed under President Truman's administration, highlighted the major advantage of regionalizing health care in these words:

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> One of the best ways of taking care of medical emergencies as well as the routines of daily medical care, is to get all local health agencies to work more smoothly together. Regionalization calls for the mobilization and development of all health resources and services in a particular region. Regionalization is the organization and coordination of all health resources and services within a defined area, for the purposes of maintaining the highest possible level of medical care, and of adopting a comprehensive health program to the characteristics and needs of the area. This way of being efficient and at the same time preserving local autonomy, customs, and characteristics, fits the American scene.[1]

The above quotation makes it clear that health problems tend to be regional in nature. This is true because the causal factors that give a locality an over-all regional identity are the same ones that create particular health problems. The relationship between health factors and economic activity illustrates this point. It is precisely because ways of living and making a living follow regional bounds that there is a coincidence of economic and health variables.

The basic philosophy of regional planning is that efficiencies can be achieved through the decentralization and redistribution of health care services in terms of meaningful aggregates of people. Basic to this philosophy is the assumption that regions should be determined through use of empirical techniques. Areas worked out arbitrarily by non-specialists in regional planning obviously invite questions of validity.

Although the utility of meaningful regions for planning and administrative purposes represents the major advantage of such delineations, there are at least two other justifications for defining such areas. One is that regional entities provide ideal units for data collection and reporting. Properly selected regions are homogeneous, a characteristic that obviates much of the necessity for detailed analysis of quantitative information. In the second place, regions provide advantages for research and evaluation. Sampling can be done more readily on a regional basis, as can evaluation of programs and assessment of change. All in all, there is much logic to support regionalization.

Theoretical and Conceptual Frame of Reference

The procedure developed for delineation of health service and planning regions for Louisiana was somewhat complex. (A bibliography of the methodology references is presented in Appendix A.) By way of introduction to the conceptual approach followed, it may be noted that within the discipline of sociology composite regions have been primarily delimited in terms of the presence of uniform or homogeneous characteristics.[2] Rationalization for this type of approach was founded on the basic assumption that social and economic characteristics were closely correlated within a given population aggregate.[3]

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[1] The President's Commission on Health Needs of the Nation, Building America's Health, Vol. 2, 1951.

Traditionally, the procedure for regional delineation based on a homogeneity of characteristics involved correlation analysis or more complex factor analytic techniques. The major advantage of this type of procedure was that it allowed the inclusion of a large number of variables in the delineation. The generalized procedure followed in this type of regional delineation can be summarized in the following manner. Data representing the phenomenon under consideration are collected and indices summarizing these data developed. Redundant and unreliable indices are rejected prior to analysis. If simple correlation analysis is to be used, variables showing high intercorrelations with other characteristics and low intercorrelation among themselves are selected for use in the regional delineation.

When the more complex factor analytic techniques are followed, the variables used in the regional delineation are selected because they display high intercorrelations among themselves. Additionally, these variables are weighed on the basis of their correlations with a more inclusive factor. (This process will be described at more length in the following section.) Both correlation analysis and factor analysis procedures represent efficient means of selecting variables which are relevant to the delineation at hand.

The next step in the traditional delineation procedure is to obtain a distribution of values based on the. original data for the selected variables. Cutoff points are established which group areal units with similar (homogeneous) values into subregions.

There are both advantages and disadvantages involved in the above procedure. The major advantage, cited previously, is that this type of analysis employs a large number of variables that are selected on the basis of relevance. The disadvantages of this procedure are inherent in the assumption that homogeneity is the major consideration in the delineation of composite regions. Such an assumption overlooks certain problems. For one thing, the regions resulting from this type of analysis are not inherently contiguous. Administratively, noncontiguous regions can be unwieldly and within-region cooperation becomes difficult due to the physical separation of theoretically-alike spatial units. A second disadvantage of regional delineations based on homogeneity is related to urban places. Urban centers and the peripheral or surrounding area attached to them typically form a region that is based more on interdependence than on homogeneity.

In considering the above limitations of the traditional approach to regionalization, it became evident that a more appropriate approach would have to be utilized for delimiting health and medical care regions. Such a conclusion was implicit in the knowledge that urban centers are a dominant force in medical and health care services. This realization led to the consideration of the second basic model for regional delineation, known as the gravitational model. This model is based on the known influence of urban places or nodes on their surrounding area. Its theoretical base rests squarely on the assumption of an interchange between these centers and their peripheral areas. The intervening areas between nodes are conceived as divisible into regions. Isard explains this view as follows:

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[2] Single factor regions do not present the problem of determining homogeneity among a set of variables, but rather variations along a continuum.

[3] Margaret J. Hagood, Nadia Danilevsky and Corlin O. Beum, "An Examination of the Use of Factor Analysis in the Problem of Subregional Delineation." *Rural Sociology* 6, No. 3. (September, 1941), p. 219.

> The mass is structured according to certain principles. These principles govern in an over-all fashion the range of behavior of the individual particles, both constraining and initiating their actions.[4]

G.A.P. Carrothers presents the reasoning behind the gravity model in more specific terms:[5]

1. To produce interaction, individuals must be in communication, directly or indirectly, with one another.
2. An individual, as a unit of a large group, may be considered to generate the same influence of interaction as any other individual.
3. The probable frequency of interaction generated by an individual at a given location is inversely proportional to the difficulty of reaching, or communicating with, that location.
4. The friction against this transportation or communication is directly proportional to the intervening physical distance between the individual and the given location.

This relationship may be expressed in the following manner:

$$I_{ij} = \frac{f\ (P_i, P_j)}{f\ (D_{ij})}$$

where: I_{ij} = interaction between center i and center j

P_i, P_j = population of areas i and j

D_{ij} = distance between center i and center j.

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[4] Walter Isard, *Methods of Regional Analysis: An Introduction to Regional Science.* New York: John Wiley and Sons, Incorporated, 1960. p. 494.

[5] G.A.P. Carrothers, "An Historical Review of the Gravity and Potential Concepts of Human Interaction." *Journal of the American Institute of Planners,* 22, 1956, p. 94.

Despite serious attempts to correct it, one weakness has persisted in gravitational models. This is the inability to incorporate a large number of variables as a measure of mass. It has been possible to weigh a primary factor such as population with measures such as income or school enrollment.[6] However, the inclusion of a large number of variables has not been possible.

The limitations of the two models described were such as to raise a question regarding their use in delineating health service and planning regions. At the same time, the peculiar advantages of both the "homogeneity" and "gravitational" models could not be overlooked. Thus, an attempt was made to develop an approach that would incorporate the strengths of the two models and, at the same time, overcome their limitations. In this effort, it was reasoned that factor analysis could logically be used as a synthesizing device for data that could then be incorporated in a gravitational formula. In this way a synthesis of the homogeneity and gravity models is achieved.

The problem of additivity across factors necessitated the structuring of variables in such a way that a pure, unambiguous factor could be developed. A single score (factor score) could then be used as the mass component in the gravitational model. Single purpose nodal regions could subsequently be delineated using a multiplicity of variables instead of a single indicator. How this was done is explained in the following discussion. From a conceptual standpoint, the procedure developed assumes there are certain societal characteristics centered in urban places, and that urban places in turn are the core areas of health services and programs in the state.

Delineation of Health Service and Planning Regions

The first step in the procedure followed for delineating health service and planning regions in Louisiana was collection of information related to medical personnel and facilities. An extensive search was made in order not to overlook data appropriate to the study. In this regard, the lack of potentially useful data by city and parish breakdown was a handicap. In some cases, data were available but not current enough to justify use, and in other instances current data were available but were not felt to be valid or significant.

Twelve arrays of data (variables) were ultimately selected for use in establishing what was termed a medical adequacy index. It should be recognized that the medical adequacy index is not an attempt to assess the quality of services or the extent to which health needs are actually met; however, the index gives an indication of the potential for the delivery of medical services within an area. The 12 arrays were the numbers of (1) physicians, (2) medical specialists, (3) surgical specialists, (4) dentists, (5) registered nurses, (6) licensed practical nurses, (7) medical technologists, (8) radiologic technologists, (9) physical therapists, (10) dietitians, (11) optometrists, and (12) general hospital beds. The values for these variables for cities with populations of 10,000 or more are shown in Table 1.

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[6] Isard, *op. cit.*, p. 508-9.

Each of the above variables was related to the appropriate population base (city or parish) and expressed in ratio form (number per 1,000, etc.). Parish population projections for Louisiana were used in the calculation of ratios. These projections were taken from quarterly publications of the Louisiana Department of Public Welfare. (See Louisiana Department of Public Welfare Statistics, April, May, and June 1968.) The figures used were obtained by applying the reported natural increase to census data and increasing or decreasing estimates for migration.

Population totals for urban places with populations between 2,500 and 10,000 were not projected because of the high probability of error. Data for such places were placed in ratio form using 1960 population counts.

Computation of a Medical Adequacy Index

The second step in the procedure was computation of the medical adequacy index. This was accomplished by applying principal component factor analysis to the 12 medical variables for the areal units. In this step the relationships among these variables were reduced to a single factor and expressed in terms of a factor loading for each variable by parishes and cities. (See Table 2.) These factor loadings can be thought of as correlations of a variable with a factor.

The factor loadings of the variables were employed as weights in establishing the index of medical adequacy. This was done through utilization of factor scores. Factor scores were obtained by multiplying the individual loading of each variable on the factor times the original data and summing this product for all variables. This process yielded scores for each individual parish or city which were collectively designated as an index of medical adequacy. This index was then standardized for comparative purposes. (The derivation of this transformation is shown in Appendix B.) Such a transformation made it possible to define the absence of medical personnel or facilities as having a value of zero and to assign the indices a mean of 100. The resulting indices were such that they might be utilized for comparisons across time. Thus, a study of medical adequacy performed a decade from the time of this study could legitimately describe percentage changes in medical adequacy. The obtained values of medical adequacy for Louisiana cities of 10,000 and over are presented in Table 3.

The third step in the delineation of regions was construction of a medical influence index. To construct this index, it was necessary to allow population to have an effect on the index of medical adequacy.

TABLE 1.—Number of Medical Personnel and Number of Hospital Beds in Louisiana Cities of 10,000 or More Population

City	No. of Physicans[1]	No of Medical Specialists[2]	No. of Surgical Specialists[2]	No. of Dentists[3]	No. of Registered Nurses[4]	No. of Licensed Practical Nurses[5]	No. of Medical Technologists[6]	No. of Radiologic Technologists[7]	No. of Physical Therapists[8]	No. of Dietitians[9]	No. of Optometrists[10]	No. of Hospital Beds[11]
Abbeville	14	0	3	8	27	37	6	3	1	1	0	79
Alexandria	86	17	40	39	286	115	34	22	1	9	5	405
Bastrop	11	0	1	4	44	72	21	3	0	3	3	122
Baton Rouge	304	76	103	127	877	503	101	60	6	48	20	1,016
Bogalusa	21	2	9	10	118	143	2	3	0	2	5	204
Bossier City	12	4	3	6	139	84	8	14	1	1	2	101
Crowley	16	3	6	6	33	45	2	1	1	0	3	84
Eunice	11	2	3	8	37	33	6	9	0	0	4	85
Gretna	35	10	14	18	132	46	13	19	0	6	5	0
Hammond	8	2	4	7	62	36	7	4	1	4	3	120
Houma	41	5	13	18	153	53	11	4	2	6	5	180
Jennings	9	0	2	10	23	27	3	1	0	1	4	9
Kenner	5	0	0	6	60	37	2	5	0	0	1	0
Lafayette	115	21	41	33	286	188	50	27	2	17	6	609
Lake Charles	96	19	35	49	269	221	26	17	4	9	10	527
Minden	14	3	3	10	44	17	0	0	0	1	2	60
Monroe	106	21	38	34	225	175	23	30	3	9	6	522
Morgan City	17	1	3	10	61	25	5	5	2	1	3	94
Natchitoches	12	2	1	2	57	25	7	5	1	2	2	85
New Iberia	32	4	9	13	70	75	9	7	2	1	3	138
New Orleans	1,638	437	646	403	2,120	1,526	230	167	37	78	58	4,443
Opelousas	32	4	11	12	57	27	4	5	1	1	3	107
Ruston	23	6	7	8	64	41	6	3	0	7	2	100
Shreveport	330	76	145	133	832	682	110	102	13	19	11	1,723
Sulphur	13	1	3	7	49	109	7	9	0	0	2	115
Thibodaux	18	3	7	13	80	40	8	7	0	1	3	99
W. Monroe	14	1	4	4	97	114	17	0	1	0	0	102
Totals	3,033	720	1,154	1,064	7,075	4,650	896	603	91	251	178	11,129

[1] Louisiana State Board of Medical Examiners Official List (1967).

[2] American Medical Association Directory (1967).

[3] *Official List Dentists*, Louisiana State Board of Dentistry (1965-1967).

[4] Official List of the Louisiana State Board of Nurse Examiners (1967).

[5] Official Roster of the Louisiana State Board of Practical Nurse Examiners (1967).

[6] Board of Registry, American Society of Clinical Pathologists (1967).

[7] The American Registry of Radiologic Technologists (1968).

[8] Roster, Louisiana Chapter, American Physical Therapy Association (1968).

[9] Roster, Louisiana Dietetic Association (1968).

TABLE 2.—First Factor Loadings of Medical Variables for Louisiana Cities of 10,000 or More Population Using Principal Component Analysis

Variables	Factor loading
Physicans	.8578
Medical Specialists	.7224
Surgical Specialists	.7462
Dentists	.5210
Registered Nurses	.7961
Licensed Practical Nurses	.5875
Medical Technologists	.5187
Radiologic Technologists	.5422
Physical Therapists	.2453
Dietitians	.2914
Optometrists	.3262
Hospital Beds	.5575

TABLE 3.—Medical Adequacy Index Values for Louisiana Cities of 10,000 or More Population

City	Index value	City	Index value
Abbeville	62	Lake Charles	81
Alexandria	117	Minden	49
Bastrop	57	Monroe	96
Baton Rouge	102	Morgan City	66
Bogalusa	67	Natchitoches	50
Bossier City	40	New Iberia	52
Crowley	50	New Orleans	105
Eunice	70	Opelousas	73
Gretna	96	Ruston	81
Hammond	81	Shreveport	110
Houma	90	Sulphur	83
Jennings	41	Thibodaux	86
Kenner	27	W. Monroe	70
Lafayette	142		

Thus the medical influence index was based on both population and medical adequacy. This was not a simple process. Giving equal weighting to population and medical adequacy would have yielded an index that overwhelmingly reflected population and diminished the relative effect of medical adequacy. The effect of the range of population, as opposed to the range of the medical adequacy index, would have biased the index in favor of population. These difficulties were surmounted by obtaining the product of the square root of the population and the medical adequacy index value. In order to facilitate handling of the index, this product was divided by 10. The resulting index is presented in Table 4. These medical influence index values were employed as the measure of mass in the gravitational model explained previously.

TABLE 4.—Medical Influence Index Values for Louisiana Cities of 10,000 or More Population

City	Index value	City	Index value
Abbeville	634	Lake Charles	2,053
Alexandria	1,149	Minden	558
Bastrop	703	Monroe	2,205
Baton Rouge	3,997	Morgan City	767
Bogalusa	975	Natchitoches	586
Bossier City	720	New Iberia	886
Crowley	617	New Orleans	8,336
Eunice	746	Opelousas	966
Gretna	1,420	Ruston	960
Hammond	836	Shreveport	4,463
Houma	1,344	Sulphur	890
Jennings	448	Thibodaux	1,001
Kenner	349	W. Monroe	863
Lafayette	2,850		

Actual Delineational Procedure

The medical influence index just described was constructed to determine the medical drawing power of an urban place.[7] It was translated into a measure of spatial influence through use of the gravitational model. Essentially, this meant the larger the value of medical influence for a city, the greater its influence over the surrounding area. An illustration of this is found in the relative medical influence values for Baton Rouge (3,997) and New Orleans (8,336). In this instance, the medical influence value for Baton Rouge is a little less than half the value for New Orleans. Translated into spatial terms, the regional boundary between Baton Rouge and New Orleans could be drawn at a point approximately one-third of the distance from Baton Rouge to New Orleans. If the medical influence values for the two cities were identical, the boundary would be drawn exactly halfway between the cities.

The delineation procedure was first applied to the seven most populous urban areas in Louisiana. The results are shown in Figure 1. The areas surrounding urban centers can be looked upon as repre-

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[7] The basic conceptions involved in the form of gravitational model employed here are found in William J. Reilly, *The Law of Retail Gravitation,* New York: Knickerbocker Press, 1931. The specific formula for the regional delineation was taken from R. M. Northam, James A. Barnes and James E. Lewis, *Functional Regions of Georgia: Their Delimitation and Nature,* Athens, Georgia: University of Georgia, Institute of Community and Area Development and Department of Geography, 1963. It represents a circle having a radius of $D\sqrt{I_1I_2}/(I_1\text{-}I_2)$ and a center located at $DI_2/(I_1\text{-}I_2)$ beyond I_2 when measured in a straight line where: D represents the distance between two cities and $I_1$and I_2 represent the relative influence (along any selected dimension) of the two cities, with I_1 being greater in influence than I_2.

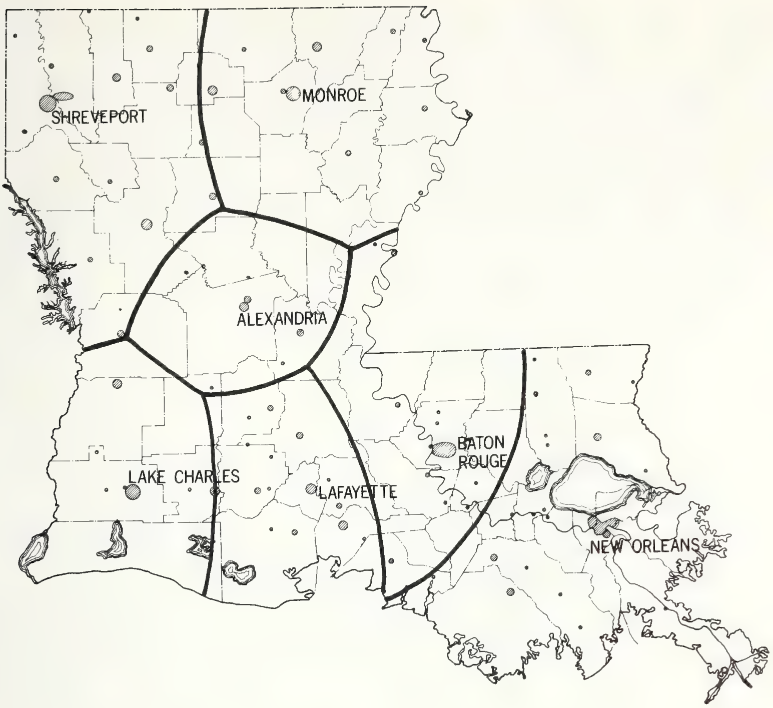

FIGURE 1.—Relative spheres of medical influence of seven major urban areas of Louisiana, 1969.

senting unaltered spheres of medical influence; i.e., not adjusted to natural or political boundaries.

Practical considerations dictated the necessity of delineations coinciding with political boundaries. This requirement involved a further procedural step to assign parishes bisected by medical influence boundary lines to one region or another. In doing this, it was felt wise to consider three factors influencing the behavior of individuals. First, the influence of smaller cities had to be taken into account. In other words, these smaller centers were thought to be critical in pulling people into one region or another. Second, the existence of natural barriers limiting access to a regional center was considered. The presence of a river or lack of roads obviously might direct the flow of patients or clients in one direction or another. Finally, what might be termed social or cultural factors (such as a pattern of patronizing a hospital or specialist) were deemed important for a group of people, even though they lived outside a region.

In order to account for the influences listed above, two strategies were employed. The first was determination of the medical influence of urban places with populations of 10,000 or more, as shown in

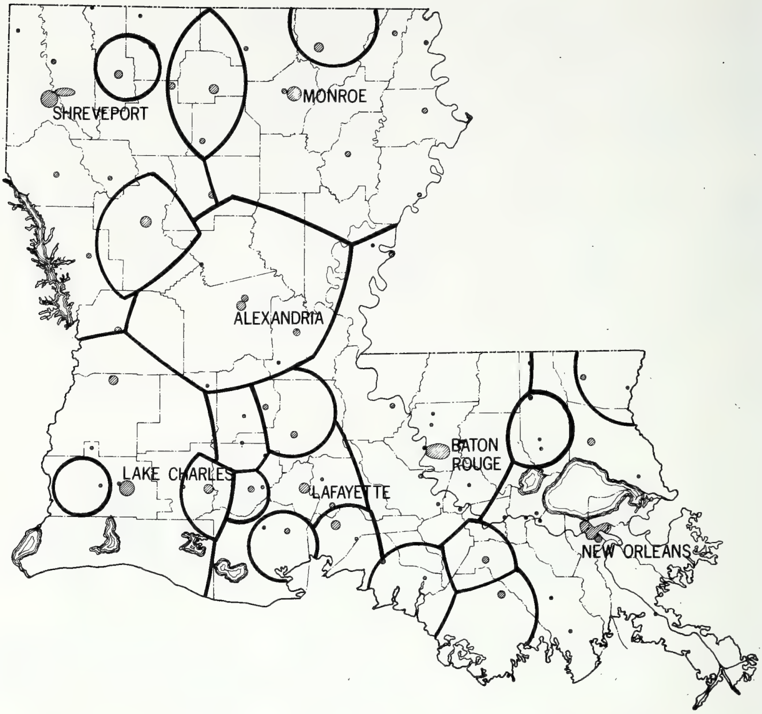

FIGURE 2.—Relative spheres of medical influence of Louisiana cities of 10,000 population or greater, 1969.

Figure 2. Earlier investigation indicated that urban places with populations between 2,500 and 10,000 did not uniformly contain sufficient medical personnel and facilities to act as centers of medical influence. It can be noted in Figure 2 that overlapping spheres of medical influence exist. This overlapping was an aid in adjusting the delineation in Figure 1 to parish boundaries. For instance, in the case of Natchitoches the medical sphere of influence of this city is primarily within the major region centered on Shreveport. There is, thus, an indication that Natchitoches Parish would appropriately be assigned to the Shreveport region.

The strategy of delineating the influence areas of smaller urban centers was followed by personal interviews with leading and knowledgeable persons, such as hospital administrators and physicians, in each of the critical areas. As a result of this field work, parishes for which there was some question could be assigned to one of the seven basic nodal regions. The nine most questionable parishes were Allen, Assumption, Catahoula, Concordia, Lincoln, Natchitoches, Tangipahoa, Vernon, and Winn.

Allen Parish required field work to determine its placement in a planning district. Statistics indicated a relatively greater dependency on Alexandria than Lake Charles. In 1968, dependency for obstetric services in both private and charity cases showed a definite balance toward Alexandria.[8] In addition, professionals there identified Oberlin as a dividing point from which residents north of that point go to Alexandria and those south of that point go to Lake Charles. The relative population concentration of Allen Parish indicates a slight majority in the north of the parish. All of these considerations lead the researchers to conclude that Allen Parish should be aligned with the Alexandria district, although it would obviously be more appropriate to divide the parish so that its southern part would be in the Lake Charles region.

The gravitational model placed more of Assumption Parish in the Baton Rouge region than in the New Orleans region, although interviews in the parish revealed that most referrals are made to New Orleans. In 1968, New Orleans handled 143 charity births and no private births from Assumption Parish.[9] However, no births from Assumption Parish occurred in any other regional center. In this regard, one physician did indicate that Baton Rouge would probably receive more referrals as its medical services increased, due to its geographic proximity.

Interviews verified that most referrals from Catahoula and Concordia parishes are made to Natchez, Mississippi. The persons interviewed in Catahoula Parish noted that referrals to Alexandria were slightly more common than referrals to Monroe; however, they emphasized that the physicians located in Catahoula Parish were members with those of Concordia and Tensas parishes in the Tri-Parish Medical Society, which favored alignment with the Monroe planning district. Recently, at the request of this society, these parishes were placed in the Monroe region by the Louisiana Interdepartmental Health Policy Commission.

Interviewees in Lincoln Parish expressed a preference for the Monroe region rather than the Shreveport region, even though the bulk of the charity births from Lincoln Parish occur in Shreveport.[10] This position appears in keeping with the fact that twice as many private births from Lincoln Parish occur in Monroe as in Shreveport.

Interviews with health professionals in Natchitoches Parish confirmed that this parish is logically aligned with the Shreveport region. A large majority of the private referrals were reported as made to Shreveport. The charity and private births that occur outside the parish also tend to be in Shreveport, but are not as strong an indicator of regional patterns as the total referrals reported by interviewees.[11]

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[8] Baird, Beverly, "Staff Study on Medical Subregions," New Orleans, Louisiana: Louisiana Regional Medical Program, Inc. (p. 34).

[9] Ibid. (p. 14).

[10] Ibid. (p. 41 & 47).

Tangipahoa Parish provides for most of its own health needs, including charity patients who are treated almost exclusively within the parish at the Lallie Kemp Charity Hospital. Professionals in the northern part of the parish reported they refer more patients to Baton Rouge than New Orleans, but physicians in the southern portion said a large majority of their referrals are to New Orleans, and there was a concensus among those interviewed that the parish should be aligned with New Orleans.

The delineational procedure followed divided Vernon Parish among three regions. However, persons interviewed in this area were in complete agreement that the parish should be aligned with the Alexandria planning region. There seems to be little reason to question this position, as Alexandria was the only regional center that handled either charity or private births from this parish in 1968.[12]

Winn Parish was also divided among three regions—Shreveport, Monroe, and Alexandria—by the delineation formulas used. Interviews with professionals did, in fact, reveal that referrals reflected such a coincidence of influence. However, interviewees were in complete agreement that Winn Parish should be placed within the Alexandria region. In support of this view, it may be noted that a few Winn Parish births occurred in Shreveport in 1968, but the large majority of births from parish residents that occurred outside the parish were deliveries in Alexandria.[13] This choice reflects the greater accessability of Alexandria to Winn Parish.

The ultimate regional division worked out is shown in Figure 3. This delineation of health regions represents what might be termed a primary delineation.

There are possible alternatives that could be worked out on the basis of the influence factors previously mentioned. For example, field work in the northwestern section of the state indicated medical practitioners in the Ruston area were interested in an eighth medical region, centered in Ruston and including the parishes of Union, Lincoln, Bienville, and Jackson. This alternative delineation is shown in Figure 4. However, the indicators of medical influence worked out for Ruston did not warrant a separate medical region. Nevertheless, it is recognized that local cultural factors are, in some instances, more important for regional delineation than objective criteria. Individual planners will have to decide if these factors are important enough in the Ruston area to warrant separate consideration.

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[11] Ibid. (p. 34 & 41).

[12] Ibid. (p. 34).

[13] Ibid. (p.34).

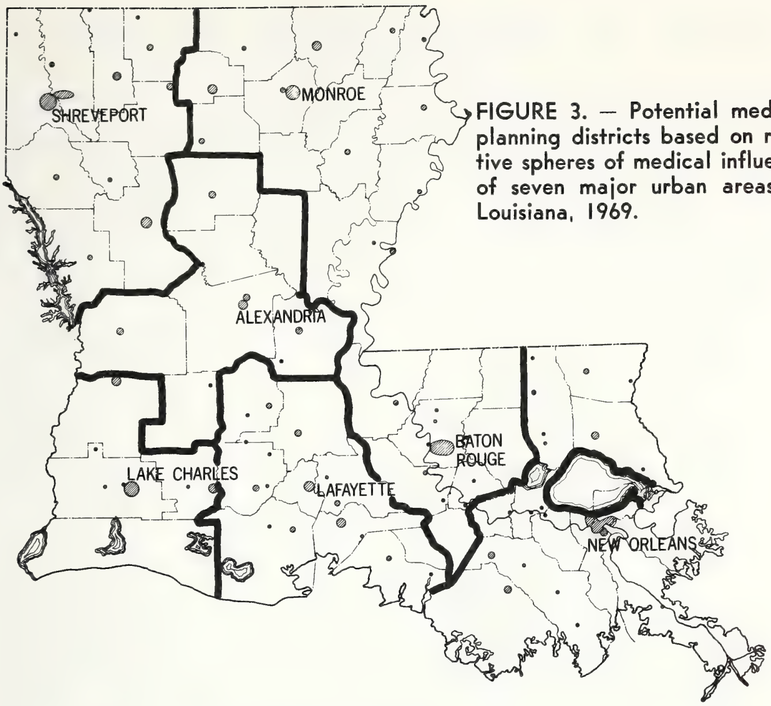

FIGURE 3. — Potential medical planning districts based on relative spheres of medical influence of seven major urban areas of Louisiana, 1969.

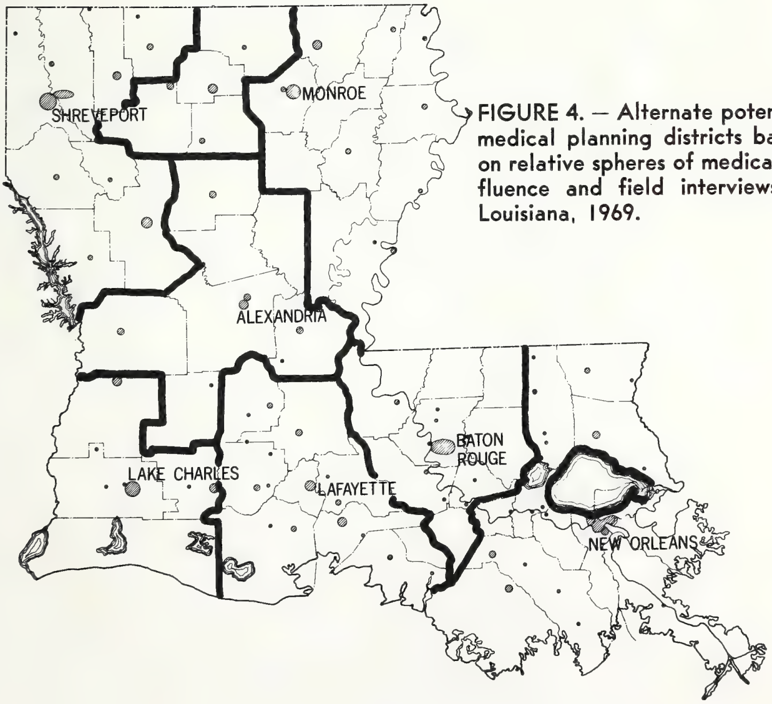

FIGURE 4. — Alternate potential medical planning districts based on relative spheres of medical influence and field interviews in Louisiana, 1969.

Comparison of Regions Delineated With Other Regional Schemes

The investigation made in connection with the delineation of health service and planning regions for Louisiana disclosed numerous regional subdivisions of the state. As was pointed out in the introduction, essentially every agency functioning in Louisiana utilizes an implicit or explicit subdivision of the state for planning and administrative purposes. On the basis of the work done, it was estimated that well over a hundred such delineations are in use in the state. Some of these areal divisions were obviously drawn on the basis of intuition, while others were based on one level or another of empirical data. The one generalization that can be made about all these delineations is that they are not identical. Six of them are depicted for illustrative and comparative purposes in Figures 5 through 10. It can be seen that they represent a wide latitude of approaches, ranging from delineations based on health to those based on economic and demographic factors, and still others based on sociocultural factors.

Study of Figures 5 through 10 readily indicates agreement on what might be termed the core areas of regions in the state. This is simply a manifestation of the known influence of these central places on their surrounding areas. However, it is also obvious that little agreement exists regarding the outer boundaries of regions. This phenomenon highlights the problem which prompted this study.

Figure 5 represents the health planning subdivisions of the state which come closest to the delineation presented in this report. This particular regional delineation was worked out according to a rather sophisticated methodology, but its data base was limited to the population of urban centers. That is, a single indicator was employed in the delineation procedure. Since the present delineation was accomplished through a statistical synthesis of population data and medical personnel and facilities data into a single index, it is felt that it is more appropriate and valid for health regions. Nevertheless, comparison of the two delineations demonstrates the close relationship between the population base and health factors in given areas. In a general sense, this inter-relatedness is carried over to economic variations in the state, which assume a nodal perspective. The regions shown in Figures 9 and 10 are based on economic variables and with minor exceptions coincide with the delineation presented in this report. The relative coincidence of medical, population, and economic subregions is not surprising in view of a preliminary study that showed economic variables and population density to be very closely related to medical adequacy. This finding and the fact that almost all other regional delineations have identical core areas have implications for regional planning. There is an obvious indication that all types of regional programs—economic, educational, health, control, etc.—can be integrated into one set of regional divisions. Potential savings in time and resources would seem to justify planning in this direction.

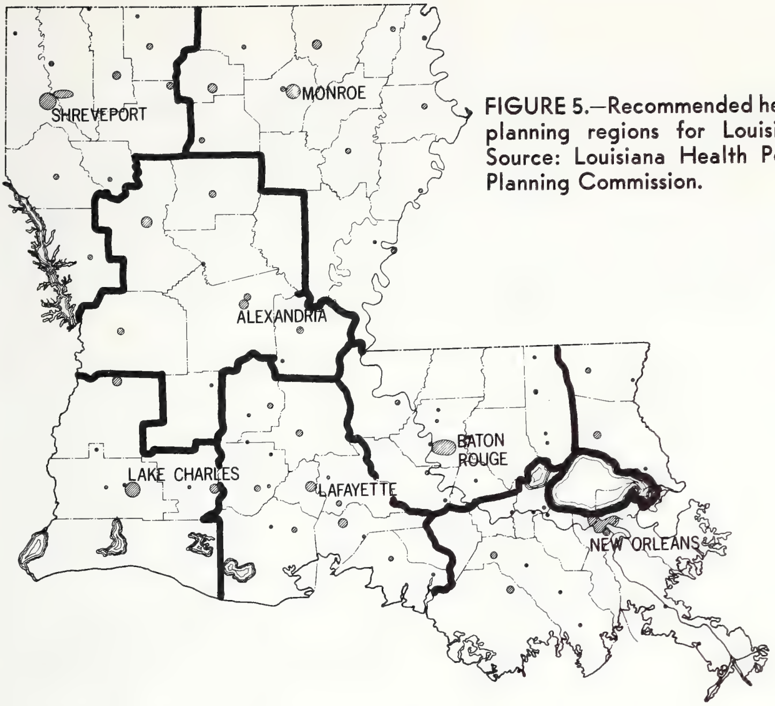

FIGURE 5.—Recommended health planning regions for Louisiana. Source: Louisiana Health Policy Planning Commission.

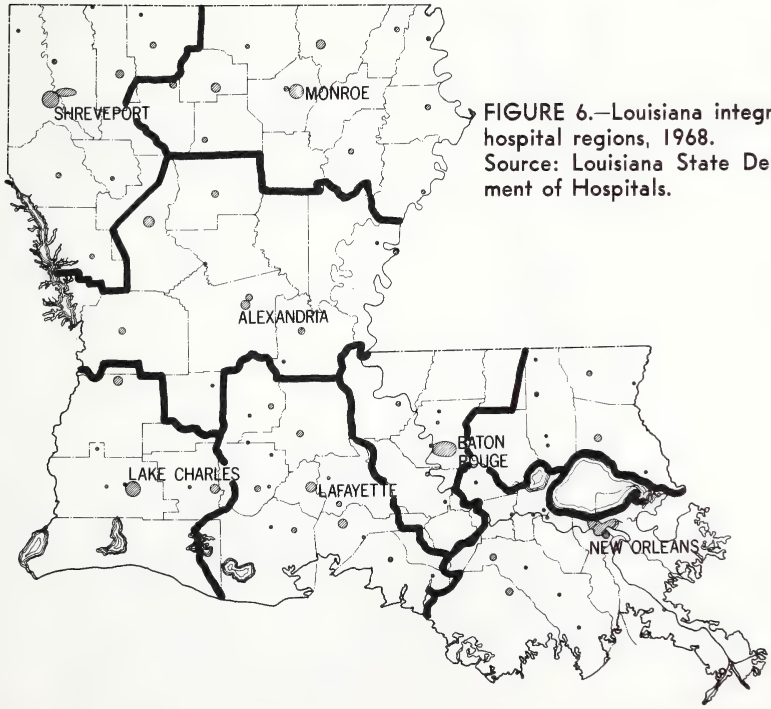

FIGURE 6.—Louisiana integrated hospital regions, 1968. Source: Louisiana State Department of Hospitals.

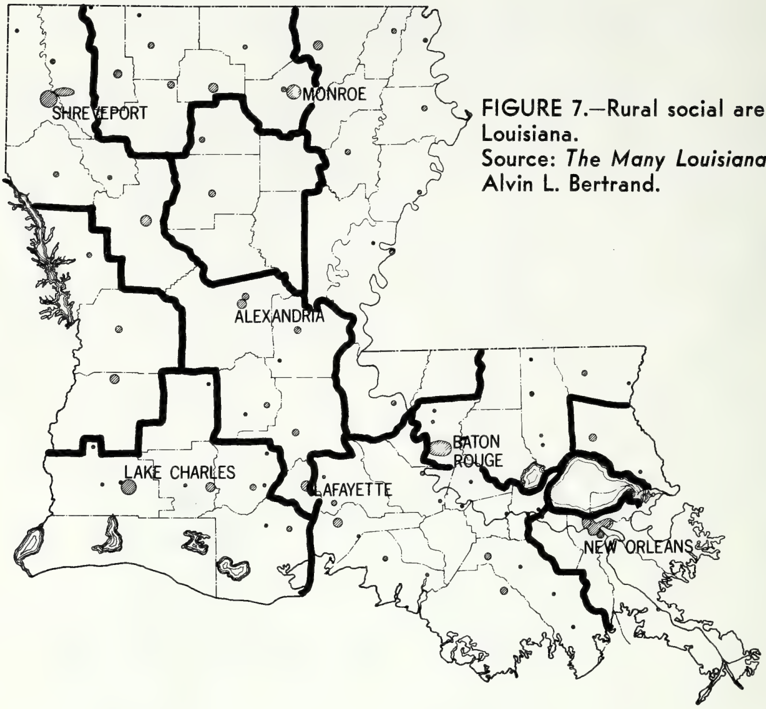

FIGURE 7.—Rural social areas of Louisiana.
Source: *The Many Louisianas*, by Alvin L. Bertrand.

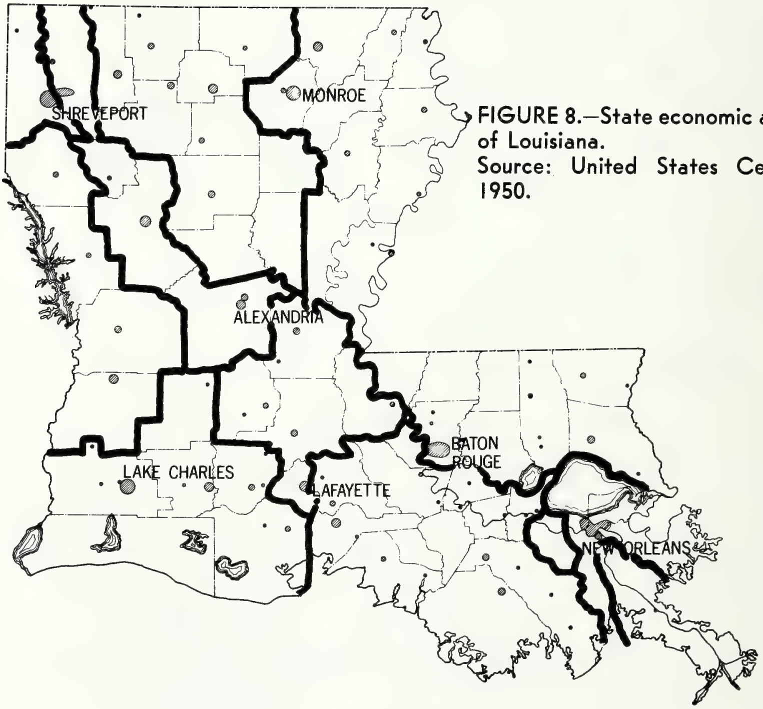

FIGURE 8.—State economic areas of Louisiana.
Source: United States Census, 1950.

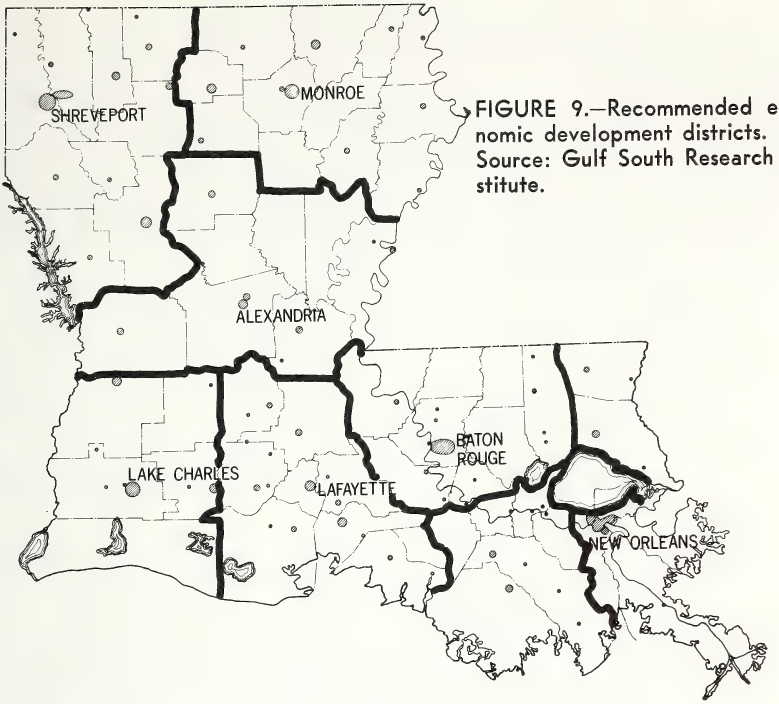

FIGURE 9.—Recommended economic development districts. Source: Gulf South Research Institute.

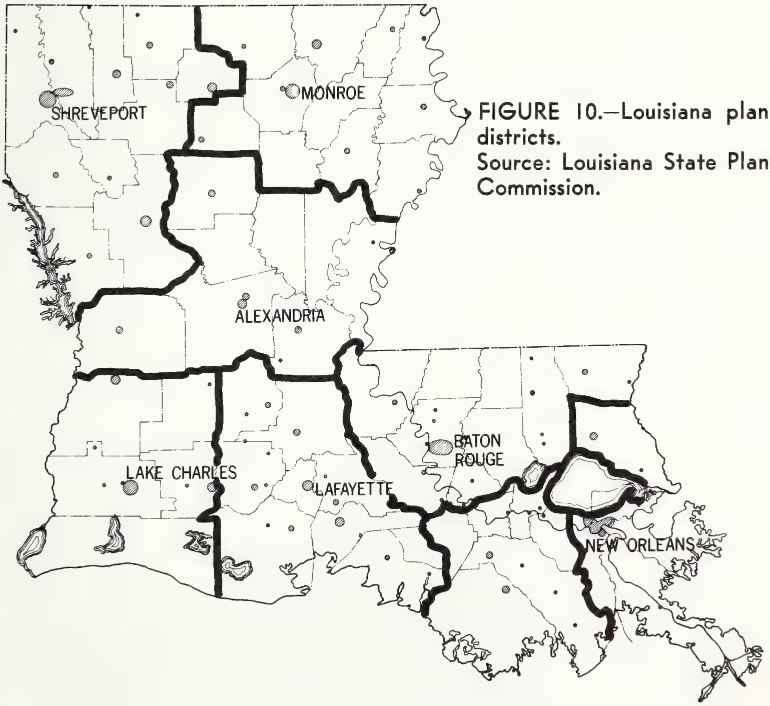

FIGURE 10.—Louisiana planning districts. Source: Louisiana State Planning Commission.

Conclusions and Implications

This study leads to several conclusions that seem worthy of serious consideration because of the implications they have for health and medical care programs in the state. These conclusions may be stated briefly as follows:

1. The need for and utility of regional divisions within the state are widely recognized and are evidenced by the large number of regional schemes now in use.
2. It is apparent that with a few exceptions very little has been done to coordinate and validate the regions used by various agencies and departments.
3. Until the present study, no delineation effort in the state has been primarily based on medical adequacy criteria.
4. There is a statistically demonstrable interrelationship between economic and demographic variables and the level at which health and medical care services are available.
5. The 64 parishes of the state are divided into seven composite regions when a measure of medical adequacy is used as a delineational tool.
6. Certain mitigating factors serve to complicate administration and planning for health and medical care programs, including the proximity of large urban centers in neighboring states and the patterns of use of hospitals and other facilities established over time.

Several implications related to the delivery of health and medical services are inherent in the above conclusions. First, it is clearly implied that efficiencies in planning, programming, and administering such services can be effected through the use of carefully delineated sub-areas or regions. The notion which pervades here is that operations of various types could be centralized and integrated through utilization of common territorial units. It is realized, of course, that some adjustments would be necessary, but these could readily be rationalized in terms of the advantages to be gained.

The second implication is related to the first, but has a special significance. This is the obvious finding that various regions within the state have unique needs in terms of health care. For one reason or another—the economic base, the cultural base, the demographic equation or the epidemiology of disease—there is need for specialized facilities and care. Regional centers are the most appealing solution to problems of this type.

A third implication is derived from the present lack of universally accepted base units for the collection and summation of health and medical care data. With meaningful and empirically sound regional units available, data could be collected, systematized, and analyzed in terms of one set of regional delineations. This practice would make comparisons possible that now are out of the question because each agency summarizes its data according to its own regional plan. In addition, longitudinal and experimental studies could readily and easily be inaugurated, as could evaluative studies of one type or another.

A fourth implication of the study is the potential the procedure worked out and used has for application in other states and territories. There is a strong indication, backed by a validation check in another state, that the delineational procedure followed can be performed and have useful application elsewhere. This is not to imply that adjustments and refinements in procedure may not be made, but that the conceptual framework and general analytical approach are sound.

There are other implications that relate to the strategies that will have to be employed to implement the use of the regional entities delineated, both in terms of convincing administrators of various agencies of the utility of the regions worked out and in terms of the specific adjustments each agency will have to make. However, these matters are in the realm of long range planning and are more properly the concern of interagency councils of one type or another.

Appendix A

Methodology Bibliography

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Appendix B

MEDICAL ADEQUACY INDEX DERIVATION

An index with a true 0 and mean of 100 is defined:

$$I' = \alpha + \beta \; I \qquad (1)$$

where:

I' = index having true 0 and mean of 100

α = 100--value of I' when $I=0$

β = unit change in I' for one unit change in I

and:

$$I = \sum_{J=1}^{q} [f_j(\frac{x_{ij} - \bar{x}_j}{s_j})] \qquad (2)$$

where:

f_j= factor loading value for the j th class of medical personnel and facilities e.g. physicians = j = 3. j = 3,4--14

x_{ij}= number of medical personnel and facilities of the j th class residing in the i th city or county of the state. i = 1,2,---

$\bar{x}_j$= mean value for the j th class of medical personnel or facilities

s_j= standard deviation of the distribution of the j th class of medical personnel and facilities.

(Continued)

Appendix B (Continued)

Therefore:

$$I' = \alpha+\beta \ [\sum_{j=1}^{q} \{ \ f_j \ (\frac{x_{ij} - \bar{x}_j}{s_j}) \ \} \ ] \tag{3}$$

$$= \alpha+\beta \ [\{ \sum_{j=1}^{q} (f_j \frac{x_{ij}}{s_j})\} - \{ \ \Sigma \ (f_j \frac{\bar{x}_j}{s_j})\}] \tag{4}$$

and we define:

$I' = 100$

When:

$I = 0$

[note: $I=0$ when $x_{ij} = \bar{x}_j$ for all j classes of i]

therefore:

$$100=\alpha+\beta \ (0) \tag{5}$$

and:

$$\alpha = 100 \tag{5.2}$$

when $x_{ij} = 0$ for j classes, $I' = 0$;

therefore:

$$I' = 100 + \beta \ [-\sum_{j=1}^{q} \ (f_j \frac{\bar{x}_j}{s_j})] \tag{6}$$

$$0 = 100 - \beta \ [\sum_{j=1}^{q} \ (f_j \frac{\bar{x}_j}{s_j})]$$

therefore:

$$100 = \beta \ [\sum_{j=1}^{q} \ (f_j \frac{\bar{x}_j}{s_j})] = \alpha \tag{6.a}$$

(Continued)

Appendix B (Continued)

and:

$$\beta = 100 \left[\frac{1}{\sum_{j=1}^{q} (f_j \frac{\bar{x}_j}{s_j})}\right] \qquad (6.b)$$

from (4), we obtain:

$$I' = \alpha + \beta[\sum_{j=1}^{q} (f_j \frac{x_{ij}}{s_j})] - \beta[\sum_{j=1}^{q} (f_j \frac{\bar{x}_j}{s_j})]$$

since from (6.a):

$$\alpha = \beta[\sum_{j=1}^{q} (f_j \frac{\bar{x}_j}{s_j})]$$

$$I' = \beta[\sum_{j=1}^{q} (f_j \frac{x_{ij}}{s_j})] \qquad (7)$$

since:

$$\beta[\sum_{j=1}^{q} (f_j \frac{x_{ij}}{s_j})] = \beta[(f1 \frac{x_{11}}{s_1}) + (f2 \frac{x_{12}}{s_2}) -- + (fq \frac{x_{1q}}{sq})] \qquad (7.a)$$

$$= \beta(\frac{f1}{s1} x_{11}) + \beta(\frac{f2}{s2} x_{12}) -- + \beta(\frac{fq}{sq} x_{1q}) \qquad (7.b)$$

since for each j class:

β' f_j, and s_j are constants;

(Continued)

Appendix B (Continued)

we define:

$$C_j = \beta \frac{f_j}{s_j}$$

therefore from (7.b)

$$I' = C_1X_{11} + C_2X_{12} \text{ --+ } C_qX_{1q} \qquad (8)$$

$$= \sum_{j=1}^{q} C_jX_{ij} \qquad (8.a)$$

Formula (8.a) thus derived may be applied to the development of a medical adequacy index having a true 0 point and mean of 100.

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